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# GEOLOGY AND MINERAL RESOURCES OF THE SKYTOP QUADRANGLE, MONROE AND PIKE COUNTIES, PENNSYLVANIA

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COMMONWEALTH OF PENNSYLVANIA
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TOPOGRAPHIC AND GEOLOGIC SURVEY
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by **W. D. Sevon and Thomas M. Berg**
Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY

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# PREFACE

This report and the accompanying map describe and delineate the nature and occurrence of the various rock layers and surficial deposits in a 56-square-mile area of northeastern Monroe County and southwestern Pike County, Pennsylvania. Particular attention is directed to the mineral resources that may have economic importance, and to the environmental characteristics that are critical to wise land use planning. This geologic atlas will be of importance to residents in this area, planners, local officials, engineers, conservationists, and professional geologists. It will provide basic geologic information for those charged with protecting our environment and planning proper land utilization. Highway and civil engineers will be able to evaluate construction conditions and potential hazards in advance of operations. Those interested in water resources should be better able to evaluate the distribution of groundwater.

Some technical terminology is used in this report and is required for precision, but the language used has been kept as simple and concise as possible without sacrificing accuracy. It is advisable that those not well versed in geology obtain the assistance of a professional geologist in making major decisions requiring geological interpretation.

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## PLATE

(in envelope)

Plate 1. Geologic map of the Skytop quadrangle, Monroe and Pike Counties, Pennsylvania.

View to the west across Mountain Lake toward West Mountain in the northwest corner of the Skytop quadrangle. Massive ledges near the top of the mountain are sandstones and conglomerates of the Packerton Member of the Catskill Formation, which form the erosionally resistant edge of the Pocono Plateau (photograph taken from position F on Plate 1).

# GEOLOGY AND MINERAL RESOURCES OF THE SKYTOP QUADRANGLE, MONROE AND PIKE COUNTIES, PENNSYLVANIA

by

W. D. Sevon and Thomas M. Berg

## ABSTRACT

The Skytop quadrangle occupies 56.5 square miles (146.3 $km^2$) in northeastern Monroe and southwestern Pike Counties, Pennsylvania. This area is in the Appalachian Plateaus physiographic province; the extreme northeastern corner is in the Pocono Plateau section and the remainder is in the Glaciated Low Plateaus section. The Pocono Plateau escarpment is a prominent topographic feature in the northwestern part of the area.

Unconsolidated surficial deposits mask the bedrock in about 50 percent of the area. Holocene deposits include an alluvial fan at the mouth of a stream having a steep gradient, and numerous peat deposits in many low, poorly drained areas. There are several Pleistocene (Woodfordian) deposits: flat-surfaced boulder colluvium; some outwash sands and gravels currently being reworked and mixed with recently eroded sediment; numerous ice-contact stratified-drift deposits of sand and gravel; widespread reddish-brown stony till mapped as ground moraine; and an end moraine system, the Gouldsboro end moraine, which has hummocky topography and consists of mixed till and ice-contact stratified drift.

Bedrock units in the area belong to the Upper Devonian Catskill Formation and include the Long Run Member, comprising numerous cycles of gray crossbedded sandstones grading upward into red siltstones and shales; and olive-gray to grayish-red, crossbedded sandstone and conglomerate of the Packerton Member, which forms the crest of the Pocono Plateau escarpment.

There are numerous small folds with wavelengths from a few hundreds of feet to a half mile (0.8 km), plunging generally S69W at 2°. Major joint sets in the area have strike orientations of N2E, N17E, N30E, and N80E and dips generally between 80° and vertical. Numerous fracture traces are recognizable, and over half of them are oriented between N10W-S10E and N40E-S40W.

Evaluation of mineral-resource and groundwater potential, engineering characteristics, and geologic hazards for each of the mapped units indicates: there is moderate groundwater potential only in the Long Run

Member; sand and gravel is the main mineral resource, but there is some potential for flagstone; and the principal engineering problem in this area is lack of foundation support strength in some of the unconsolidated surficial deposits.

# INTRODUCTION

## PHYSICAL SETTING

The Skytop quadrangle includes 56.5 square miles (146.3 km²) in northeastern Monroe County and southwestern Pike County, Pennsylvania. The entire area is in the Appalachian Plateaus physiographic province. The extreme northwestern part of the area is in the Pocono Plateau section of the province and the remainder of the area is in the Glaciated Low Plateaus section.

The Pocono Plateau is bounded on the southeast by an escarpment having local relief up to 400 feet (120 m) (Frontispiece). Northwest of the escarpment the land surface rises gradually in a step-like fashion. The steps result from differential erosion of gently dipping, alternately hard and soft rocks having local relief of a few tens of feet or less. The remainder of the area is characterized by a linear topography trending north-northeast to south-southwest and having local relief up to 300 feet (90 m) but generally less than 100 feet (30 m). Brodhead Creek on the west and Bush Kill on the east occupy major valleys which cut diagonally across the linear topography. This linearity is the result of sculpturing by ice during glaciation but is modified locally by a series of transverse sandstone ledges. Drainage is only moderately well developed in the area, and there are numerous undrained or poorly drained lowlands and small depressions. Small lakes cover 1.2 percent of the land surface (0.7 square mile, or 1.8 km²).

The area is influenced by a humid middle-latitude continental climate characterized by long, cold winters and mild summers. Climatic data for nearby areas are presented in the Pike County soils report (Taylor, 1969, p. 78-80).

There is no significant agricultural development in the quadrangle and, where not cleared for building, the land surface is generally covered with deciduous forest vegetation. The area is utilized for primary homes and for private resorts and clubs.

Soils mapping of Monroe County is in progress, and a preliminary soils report is available (U. S. Dept. of Agriculture, 1970).

## PREVIOUS WORK

The first significant geological investigation that included the area of the Skytop quadrangle was carried out by I. C. White for the Second Geological Survey of Pennsylvania. His mapping and report on the geology of Pike and

Monroe Counties was published as Report G6 of the Second Survey in 1882. No other geologic mapping has been carried out in this quadrangle prior to this report.

Quadrangles surrounding Skytop have received considerable geologic attention in recent years. An atlas report by W. D. Sevon on the Tobyhanna and Buck Hill Falls quadrangles just west of Skytop was published in 1975. An atlas report by M. F. Bucek on the East Stroudsburg quadrangle adjacent to Skytop on the south was published in 1971. The geologic map of the Bushkill quadrangle just southeast of Skytop was published by the U. S. Geological Survey (Alvord and Drake, 1971). The Pocono Pines and Mount Pocono quadrangles immediately southwest of Skytop were issued as an atlas of the Pennsylvania Survey (Berg and others, 1977). The quadrangles north and east of Skytop are currently being mapped as part of a geologic report on all of Pike County.

The surficial geology and glacial history of the region surrounding and including the Skytop quadrangle are treated in detail by Sevon and others (1975).

# BEDROCK GEOLOGY

## CATSKILL FORMATION

### Long Run Member

THICKNESS: No total measured thickness; calculated as 5,000 feet (1,500 m) thick along section A-A′ (Plate 1). This thickness seems very excessive when compared to more precisely measured and calculated thicknesses to the southwest (Epstein and others, 1974; Sevon, 1975b; Berg and others, 1977), and may be as much as twice the actual thickness due to the presence of folds not detected because of lack of exposure.

LITHOLOGIC DESCRIPTION: Numerous cycles repeating the vertical sequence of gray sandstone fining upward to red siltstone and claystone (Figure 1); cycles vary from 20 feet (6 m) to 100 feet (30 m) thick and probably average about 50 feet (15 m); laterally variable; has some discontinuous units; maximum distance of bed continuity unknown, but some sandstone ledges have been traced on aerial photos for almost 1 mile (1.6 km) (Plate 1); underlies 99 percent of area (55.9 square miles, or 144.8 km$^2$), but over 49 percent is covered by surficial materials. *Sandstone:* gray, fine to medium grained, and well indurated; basal contacts are irregular, and there is relief up to 3 feet (1 m) on the eroded surface of underlying red claystone; generally has trough crossbedding (Figure 2) in sets 1 to 2 feet (0.3 to 0.6 m) thick at base, grading upward to finer grained and planar beds (Figure 3), frequently accompanied by change to grayish-red color; ripple bedding and climbing ripple bedding sometimes occur in the transition zone between crossbedded and planar-bedded

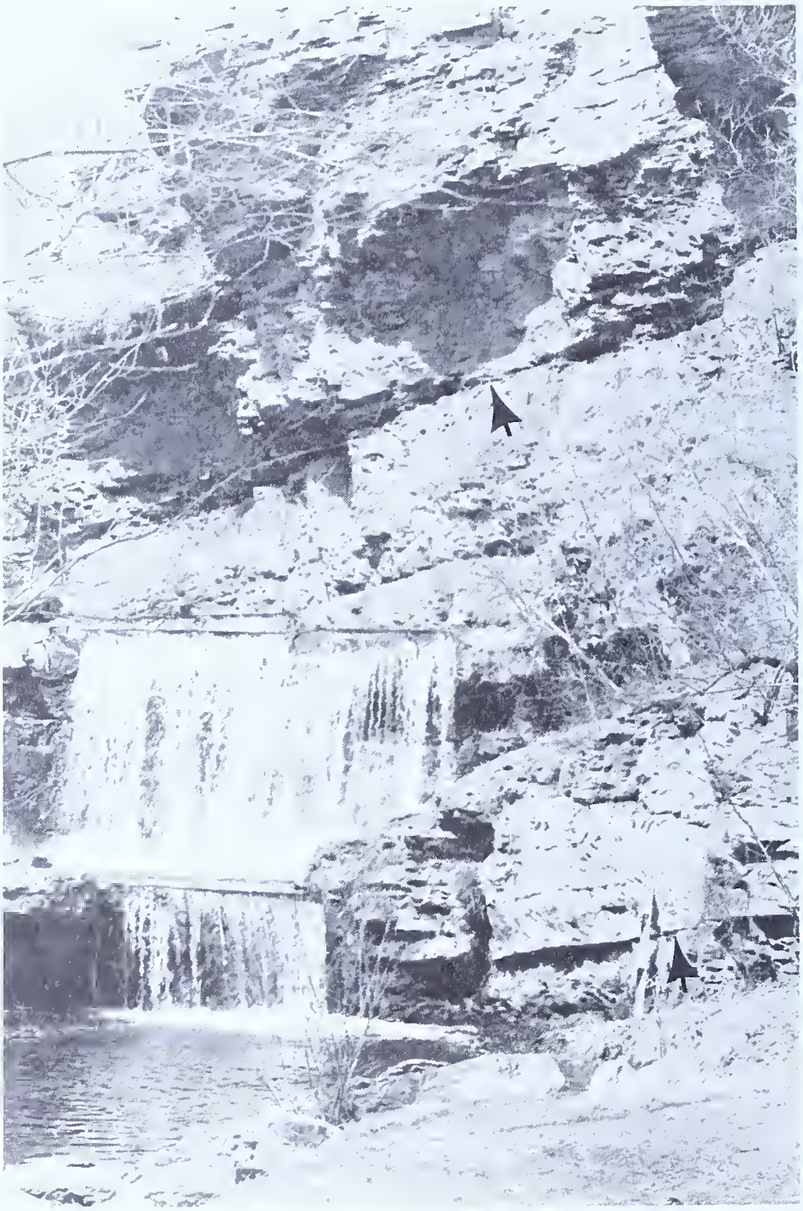

Figure 1. Repeated cycles of gray sandstone fining upward into red siltstone and claystone, occurring in the Long Run Member of the Catskill Formation at Indian Ladder Falls in the northwest corner of the quadrangle (41°14′51″N/75°13′58″W) (position 1 on Plate 1). Scale is 5 feet (1.5 m) long. Arrows indicate bases of cycles.

sandstone (Figure 4); planar beds are usually composed of 1- to 25-mm-thick laminae; planar-bedded sandstone grades upward to red siltstone; sandstone generally makes up about 50 percent of a normal cycle, but may make up over 90 percent; beds and crossbed sets are generally cemented into composite units

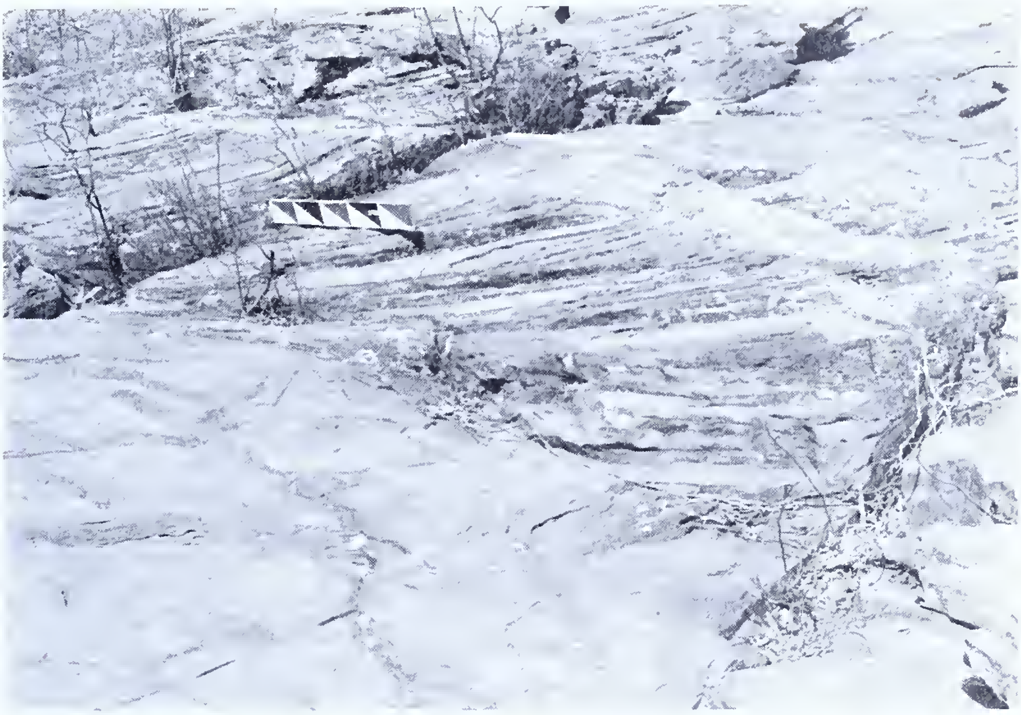

Figure 2. Bedding-surface exposure of trough crossbedding in gray sandstones of the Long Run Member of the Catskill Formation at Leavitt Falls in the northwestern part of the area (41°13′23″N/75°14′26″W) (position 2 on Plate 1). Scale is 5 feet (1.5 m) long and is oriented parallel to the trough axis. Water flow at the time of deposition was to the upper left (northwest).

3 to 6 feet (1 to 2 m) thick; sandstone initially breaks up into blocks with size controlled by composite unit thickness and joint spacing, and secondarily breaks into platy and flaggy pieces with dimensions controlled by individual bed thickness and joint spacing. *Siltstone and claystone:* coarse-grained siltstone grading upward to claystone or clay shale in frequently repeated subcycles; dominantly grayish red with some zones of greenish gray; siltstone generally composes 50 percent or more of all subcycles; generally structureless in lower parts of subcycles with gradual upward increase in invertebrate animal burrow structures as siltstone grades into claystone; claystone is generally completely bioturbated (reworked by organisms) in the uppermost part; fossils include some nearly bed-normal rootlet structures, casts of aestivation burrows of Late Devonian lungfish (e.g., borrow-pit exposure at 41°14′56″N/-75°14′20″W), and rare impressions of broken plant fragments and leaves of *Archaeopteris*; apparently abrupt change from claystone to siltstone at base of siltstone-claystone subcycles is transitional and lacks any real disconformity; claystone surface underlying sandstone of next major cycle is irregular and has 1

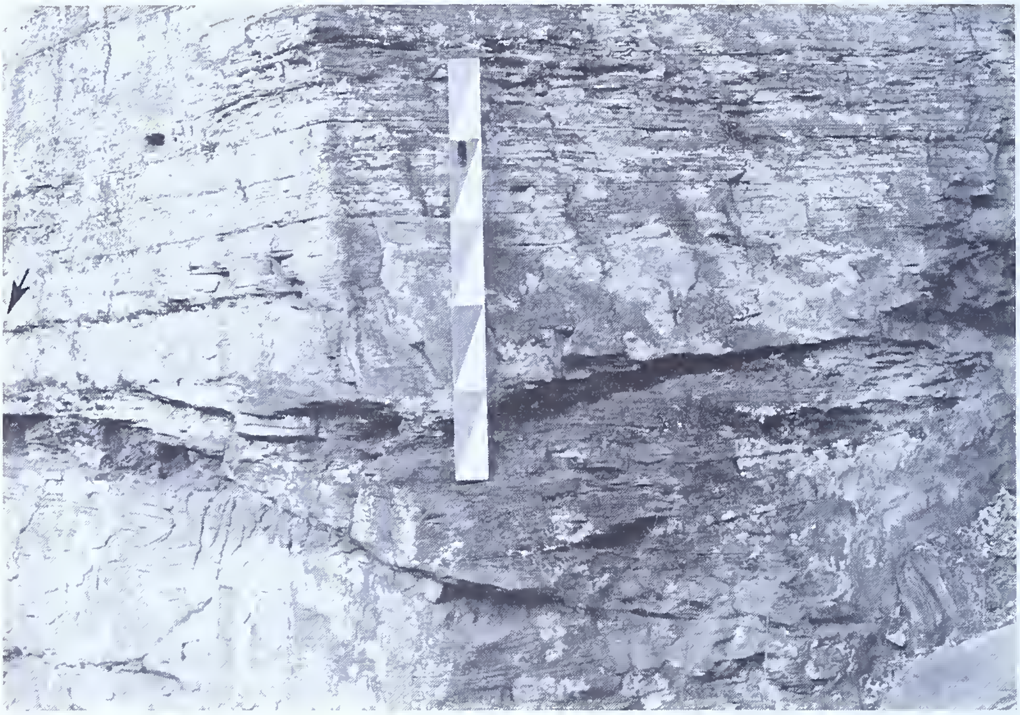

Figure 3. Crossbedded gray sandstone changing upward into planar-bedded finer grained sandstone in the Long Run Member of the Catskill Formation. The outcrop occurs along the east side of Pa. Route 447 in the southwestern part of the area (41°09′08″N/75°13′26″W) (position 3 on Plate 1). Scale is 5 feet (1.5 m) long. Arrow at left points to location of Figure 4.

to 3 feet (0.3 to 1 m) of relief; siltstone breaks up into small platy or rubbly pieces, and claystone disaggregates to hackly pieces.

CONTACTS: *Upper:* sharp; placed immediately below conglomeratic sandstone of overlying Packerton Member; occurs at top of thick (over 50 feet, or 15 m) red siltstone-claystone sequence below edge of Pocono Plateau escarpment (Figures 5 and 6); uppermost red claystone surface displays 3 to 10 feet (1 to 3 m) of known local relief, with suspected local relief of up to 30 feet (9 m). *Lower:* does not occur at surface within report area. See Berg and others (1977) for description in area to southwest. Identification in subsurface hinges on presence or absence of nonred marine Beaverdam Run Member.

GEOMORPHOLOGY: Forms terrain of moderate relief with numerous sandstone ledges developed along joint and fracture-cleavage planes (Figure 7); elongated north-northeast-trending topography in northern part results from glaciation; ledges common in southern half of area, particularly along Brodhead Creek; moderately well drained except in some areas that are choked with

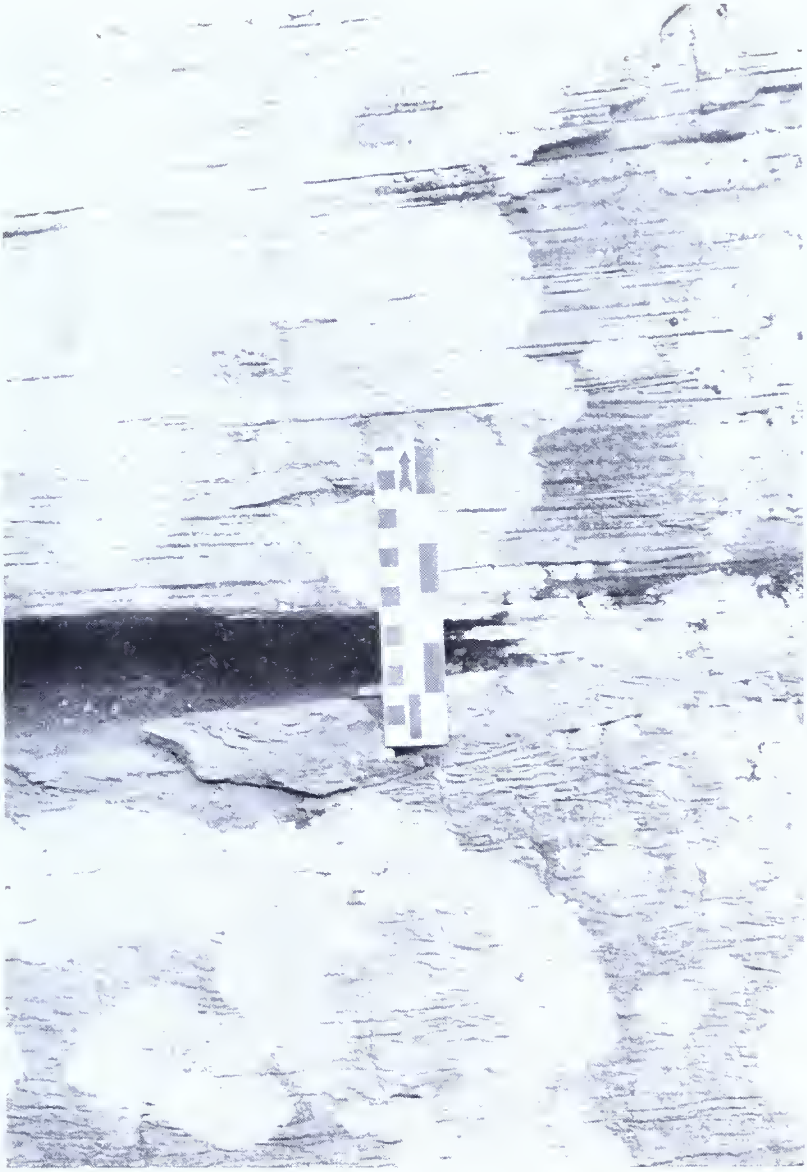

Figure 4. Ripple bedding and climbing ripple bedding occurring in a transition zone between crossbedded and planar-bedded sandstone in the Long Run Member of the Catskill Formation. The outcrop occurs along the east side of Pa. Route 447 in the southwestern part of the area (41°09′08″N/-75°13′26″W) (position 4 on Plate 1). See Figure 3 for photograph of whole outcrop. Scale is 6 inches (15.2 cm) long.

surficial deposits. Supports varied deciduous forest with scattered evergreens that grow mainly on sandstones.

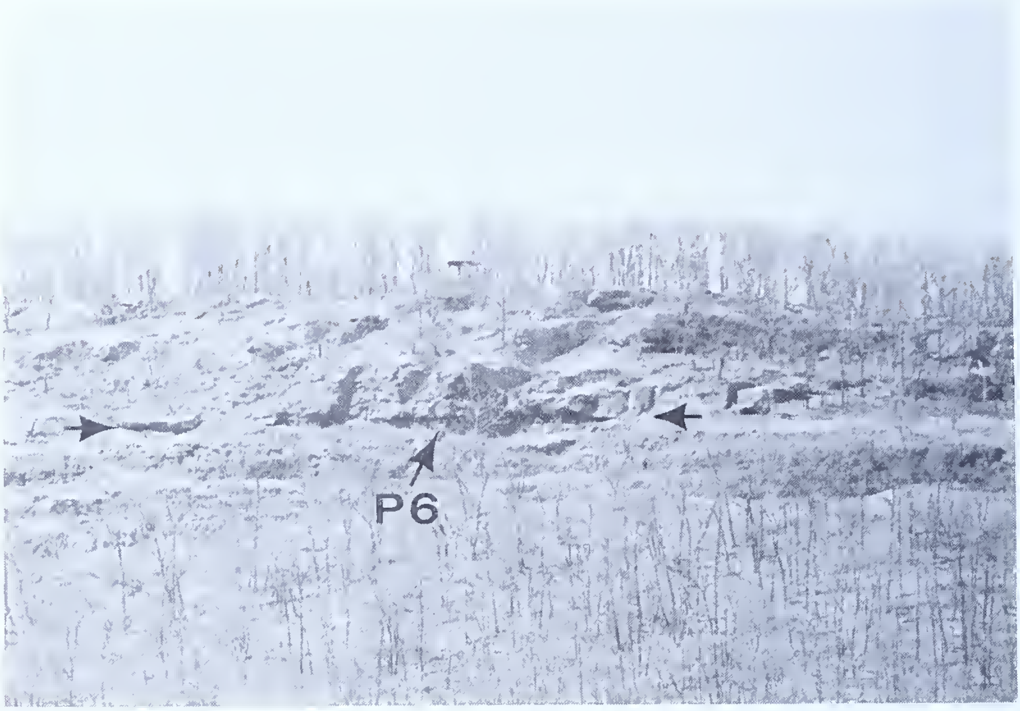

Figure 5. Uppermost part of the Long Run Member and basal part of the Packerton Member, both of the Catskill Formation, exposed on the eastern edge of West Mountain in the northwestern part of the area (41°14′15″N/75°14′21″W) (photograph taken from position F on Plate 1. Center of photograph is position 5 on Plate 1). Outcrop is also shown in Frontispiece and Figure 6. Arrows mark contact between underlying Long Run red siltstones and claystones and overlying Packerton sandstones and conglomerates. P6 is location of outcrop in Figure 6.

EXPOSURES: Numerous good exposures in hills on east side of Brodhead Creek in southwest part of area, particularly in ledges north of Snow Hill Road starting at 41°09′00″N/75°13′38″W; good outcrops at falls on Bush Kill in southeast part of area (41°09′18″N/75°08′06″W), at Indian Ladder Falls in northwest part of area (41°14′48″N/75°13′58″W), and at Leavitt Falls at Skytop in northwest part of area (41°13′22″N/75°14′30″W).

ORIGIN: Cycles of gray sandstone and red siltstone and claystone resulted from deposition in a fluvial system dominated in general by meandering rivers or streams in the upper delta plain; sandstone represents main channelways, and finer sediments represent overbank materials deposited on the floodplain. Repetition in cycles probably resulted from switching of distributaries in the lower delta plain, although some tectonic influence may have been involved.

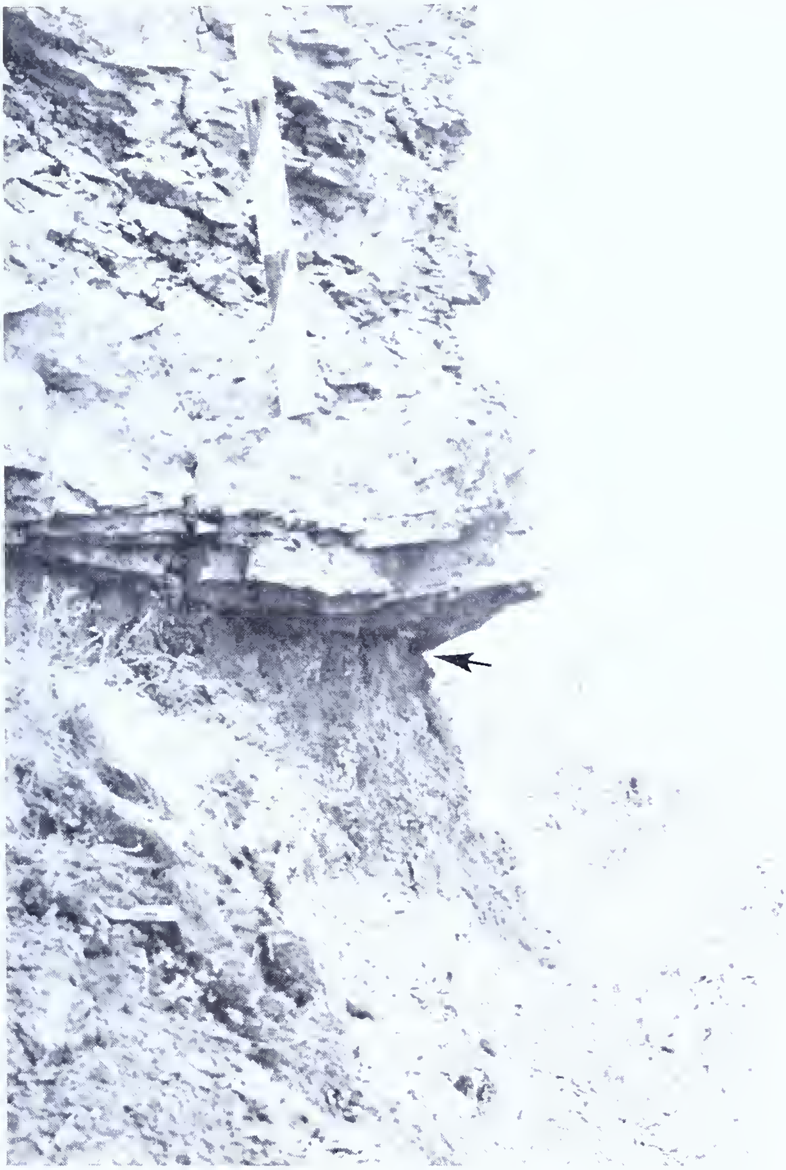

Figure 6. Contact of the Long Run Member and the overlying Packerton Member, both of the Catskill Formation, exposed on the eastern edge of West Mountain in the northwestern part of the area (41°14′15″N/75°14′21″W) (position 6 on Plate 1). Outcrop is also shown in Figure 5. Scale is 5 feet (1.5 m) long. Arrow marks contact.

Thicker gray sandstones, especially in the upper portion of the Long Run Member, may reflect increased flow velocity and increased sediment input to the fluvial system, resulting in deposition by braided rivers that had no stable floodplain to allow deposition of fine overbank sediment.

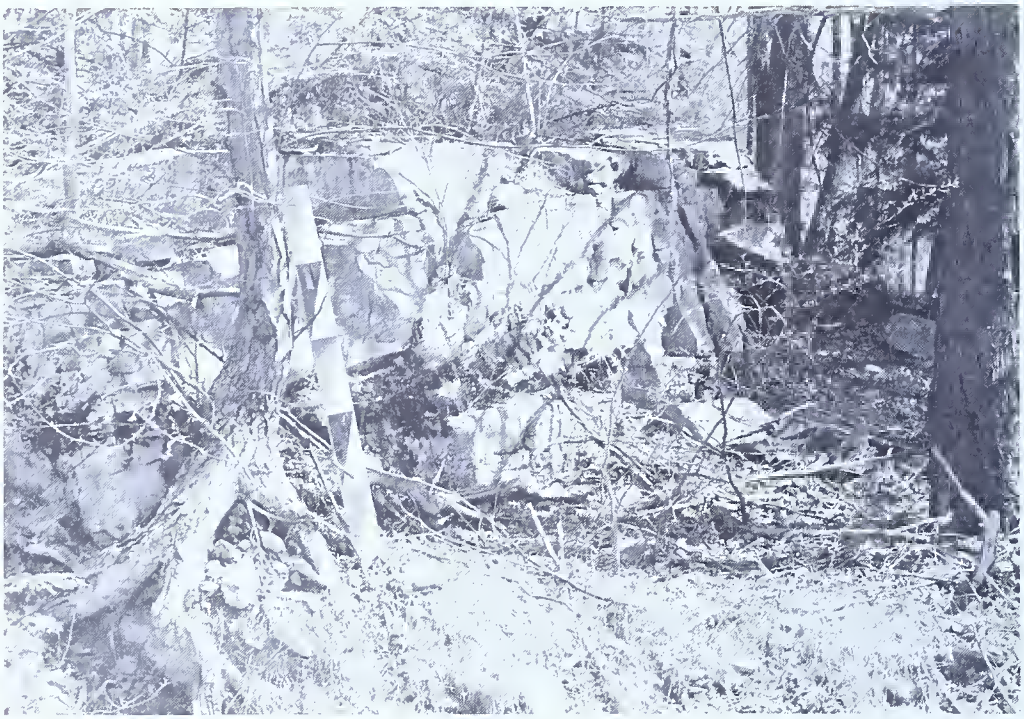

Figure 7. Typical ledge developed by weathering and erosion of gray crossbedded sandstones of the Long Run Member of the Catskill Formation. Outcrop occurs along the east side of an abandoned stretch of Pa. Route 447 in the southwestern part of the area (41°09′30″N/75°14′02″W) (position 7 on Plate 1). Scale is 5 feet (1.5 m) long. Scarp face of ledge (to right) is a fracture surface.

GENERAL COMMENTS: Member named from outcrops exposed to west along Lehigh River (Epstein and others, 1974); varies somewhat from type locality because of abundance of gray sandstone not present at type locality, but cyclicity is similar; has mappable continuity to type locality.

MINERAL RESOURCES: Some flagstone potential in planar-bedded sandstone, but limited by vertical and lateral variation; small abandoned flagstone quarry at 41°09′01″N/75°13′38″W north of Snow Hill Road in southwest part of area; no potential for dimension stone because of closely spaced partings; some potential for crushed rock because of durability, closely spaced partings, and ease of quarrying exposed ledges; red siltstone and claystone utilized for base and finish courses for low to moderate use roads because of availability, quarrying ease, and ready disintegration into small, angular fragments. Claystone intervals are possible source of structural clay products.

ENGINEERING CHARACTERISTICS: Siltstone and claystone are easily excavated with ripper except in totally unweathered, thick siltstone, which may require some blasting; sandstone is moderately difficult to excavate and may require blasting; fast drilling rates with rotary equipment in siltstone and claystone, slower rates in sandstone; maintains steep to very steep cut slopes, but closely spaced partings may result in some rockfall; claystone disintegrates rapidly into small fragments when exposed to weathering; siltstone and claystone are generally suitable for impoundments; location of sanitary landfills is limited by hardness of rock and abundant fractures and parting planes in sandstone, which allow uninhibited water movement; some difficulty with septic systems located in siltstone and claystone is to be expected; excellent to good foundation for heavy structures.

GROUNDWATER: Water well information on file at Pennsylvania Geological Survey in Harrisburg indicates groundwater potential adequate for domestic use throughout area. Data from 22 wells indicate: average total well depth of 238 feet (72 m), with range of 95 to 345 feet (29 to 105 m); average depth to solid rock of 33 feet (10 m), with range of 5 to 100 feet (1.5 to 31 m); average yield of 13 gpm (gallons per minute) (0.82 l/s), with range of 1 to 80 gpm (0.06 to 5.05 l/s); average depth of 170 feet (52 m) to first water-bearing zone and 216 feet (66 m) to second zone, with ranges of 50 to 296 feet and 63 to 335 feet (15 to 90 m and 19 to 102 m), respectively; average depth to groundwater table of 71 feet (22 m), with range of 20 to 200 feet (6 to 61 m). Greater yields probable if well is located on fracture trace or intersection of two fracture traces. Good water quality in general.

## Packerton Member

THICKNESS: No total measured thickness; calculated as 240 feet (73 m) thick along section A-A′ (Plate 1).

LITHOLOGIC DESCRIPTION: Several cycles of gray conglomeratic sandstone fining upward into red siltstone and claystone; cycles probably average about 50 feet (15 m) thick; cycles are dominantly conglomeratic (some nonconglomeratic) sandstone with only small quantities of siltstone and claystone; bases of cycles are irregular (Figure 6), with known local relief of 3 to 10 feet (1 to 3 m), and suspected local relief of up to 30 feet (9 m); cycle components are laterally and vertically variable; underlies 1 percent of area (0.6 square mile, or 1.6 km$^2$), with about 23 percent of unit covered by surficial materials. *Conglomeratic sandstone:* well-indurated, gray to grayish-red, medium- to very coarse grained sandstone with conglomeratic zones containing up to 50 percent pebbles; pebbles average ¼ to ½ inch (0.6 to 1.3 cm) in diameter with maximum observed diameter of 1½ inches (3.8 cm); pebbles are dominantly rounded to subangular white quartz, but some pebbles are reddish in color because of iron staining; few gray siltstone and claystone pebbles and occasional red claystone pebbles; greatest concentration of pebbles is usually in contiguous sets of cross strata at bases of cycles, but there are occasional inversions characterized by pebble-free basal beds grading up to beds containing increasing quantities of pebbles; trough crossbedding in sets 1 to 2 feet (0.3 to 0.6 m) thick at bases of cycles; cross strata within sets are generally 1 to 2 inches (2.5 to 5.1 cm) thick; beds and sets of cross strata are usually cemented into composite beds 4 feet (1.2 m) or more thick; composite beds initially break up into large blocks with size controlled by composite bed thickness and joint spacing, and secondarily break up into platy pieces having individual bed dimension. *Sandstone:* well-indurated, medium- to coarse-grained, gray, trough crossbedded sandstone (Figure 8) grades upward to grayish-red, fine-grained, planar-bedded sandstone; sets of cross strata are generally 1 to 3 feet (0.3 to 0.9 m) thick with individual cross strata ½ to 2 inches (1.3 to 5 cm) thick; beds become thinner upwards, and planar-bedded sandstone is generally laminated in layers ¼ inch (0.6 cm) or less thick; moderately well sorted, angular to subrounded grains with dominant size varying usually from medium to coarse grained; some silt and/or clay matrix; occasional scattered rounded white quartz pebbles up to 1 inch (2.5 cm) in diameter; breaks up along bedding and fracture planes into blocky and flaggy pieces. *Siltstone and claystone:* subfissile to massive beds generally less than 10 feet (3 m) thick; sometimes have burrow structures; siltstone grades up to shale; generally too thin for subcycle repetitions; eroded upper contact; break up into platy or hackly pieces a few inches long and fractions of an inch thick.

CONTACTS: *Upper:* not exposed in area; regionally occurs at base of red siltstone-claystone interval (of Poplar Gap Member) above well-developed conglomerate beds. *Lower:* sharp, placed at base of conglomeratic sandstone overlying thick (over 50 feet, or 15 m) red siltstone-claystone sequence of Long Run Member below escarpment of Pocono Plateau (Figures 5 and 6); known relief at base of Packerton Member is 3 to 10 feet (1 to 3 m), with suspected local relief up to 30 feet (9 m).

GEOMORPHOLOGY: Forms very prominent main edge of steep-sloped Pocono Plateau escarpment (Frontispiece and Figure 5); sandstone ledges occur in step-like fashion away from plateau escarpment. Supports varied deciduous forest.

EXPOSURES: Numerous good exposures at top of plateau escarpment and on East and West Mountains in northwest corner of area (Frontispiece and Figure 5); best exposure of base and lower part of unit is at 41°14′15″N/75°14′21″W on West Mountain, below a small wooden shelter along the trail (Figure 6).

ORIGIN: Packerton cycles formed most likely in a fluvial system receiving greater amounts of coarser textured sediment than older Catskill members; deposition by braided rivers probably dominated, but some periodically

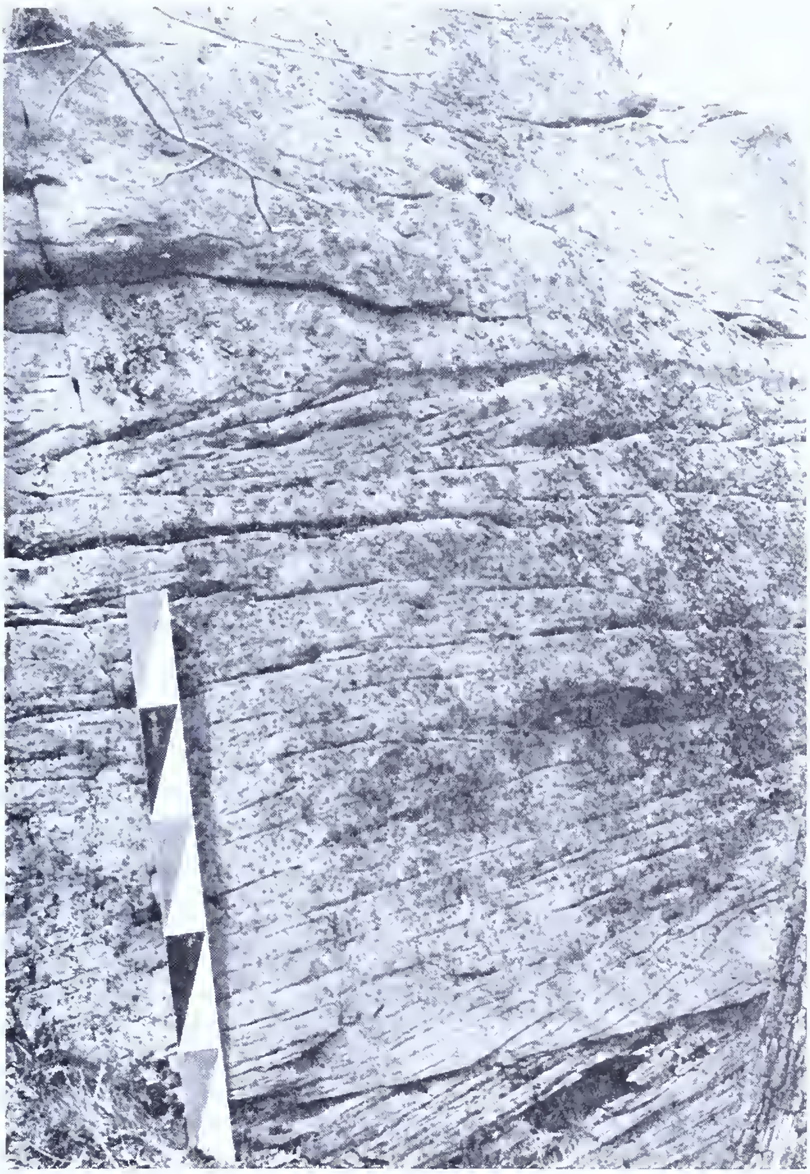

Figure 8. Trough-shaped cross strata of gray sandstones in nearly planar sets of the Packerton Member of the Catskill Formation. Outcrop occurs at eastern edge of West Mountain in the northwestern part of the area (41°14′15″N/71°14′21″W) (position 8 on Plate 1). Scale is 5 feet (1.5 m) long.

reduced flow regimes allowed establishment of meandering streams and deposition of fine overbank mud; Packerton deposition probably occurred near boundary between upper delta plain and alluvial plain.

GENERAL COMMENTS: Member named from outcrops exposed to the southwest along Lehigh River (Epstein and others, 1974); varies from type locality because of conglomeratic sandstone and red siltstone and claystone not present at type locality, but has mappable continuity into type locality. Mapping in Buck Hill Falls quadrangle immediately to the west (Sevon, 1975a) projected the overlying Poplar Gap Member of the Catskill Formation into the West Mountain area, but more detailed investigation of that area shows that the Poplar Gap Member is not present in the Skytop area. Packerton-Poplar Gap contact is less than 1 mile (1.6 km) north of the Skytop quadrangle.

MINERAL RESOURCES: No known developed mineral resources from the Packerton, although some thicker conglomeratic sandstones may have potential as dimension stone if fractures are not too closely spaced and rock is unweathered; potential as crushed aggregate is possibly limited because of coarse grain size and heterogeneous texture; siltstone and claystone are generally too thin for development as secondary road material.

ENGINEERING CHARACTERISTICS: Siltstone and claystone and some weathered planar-bedded sandstones are easily excavated with ripper, but sandstone and conglomeratic sandstone probably require blasting; generally slow drilling rates with rotary equipment; generally maintains very steep cut slopes, but closely spaced partings may result in some rockfall; use for impoundments and sanitary landfills is severely limited because of topographic position, hardness of rock, and abundant fractures and parting planes which may allow uninhibited water movement; member as a whole is generally suitable for septic systems, but shale or siltstone zones may cause some difficulty; excellent to good foundation for heavy structures.

GROUNDWATER: Little groundwater potential in this area because of topographic position and thinness of member; water production from underlying Long Run Member is more likely; may be suitable groundwater source in area north of Skytop quadrangle where overlain by Poplar Gap Member of Catskill Formation.

# SURFICIAL GEOLOGY

## WOODFORDIAN GROUND MORAINE

THICKNESS: Thickness is widely variable, partially dependent upon preglacial bedrock surface relief; thickest in valley bottoms, thinning to zero upslope; scattered data from water wells indicate average thickness of 33 feet (10 m) and range of 5 to 100 feet (1.5 to 31 m); field observations throughout report area suggest average thickness of 20 feet (6 m); drill hole data from site exploration for flood-control dams on Goose Pond Run and Leavitt Branch, both south of Skytop, indicate average thicknesses of 18 feet (5 m) and 38 feet (12 m), respectively (data from Soil Conservation Service, Harrisburg, Pa.).

LITHOLOGIC DESCRIPTION: Woodfordian ground moraine covers 34.5 percent of area (19.5 square miles, or 50.5 km$^2$). Till, basically unsorted and nonstratified mixture of clay, silt, sand, pebbles, cobbles, and boulders (Figure 9); generally reddish brown (5YR4/4)[1] to dark brown (7.5YR4/4), sometimes with pale reddish tinge; generally less than 35 percent silt and clay. Data (Soil Conservation Service, Harrisburg, Pa.) from size analyses of till recovered during site exploration for flood-control dams on Goose Pond Run and Leavitt Branch, both south of Skytop, indicate average textural composition as follows: 26 percent gravel, 47 percent sand, and 27 percent silt and clay (Leavitt Branch site); 22 percent gravel, 37 percent sand, and 41 percent silt and clay (Goose Pond Run site). Moderately cohesive; sometimes very sandy and loose, particularly in uppermost few feet of thicker accumulations; more clayey and cohesive in lower parts of thicker accumulations; clasts in till are mainly unweathered, subrounded fragments derived locally from gray or red rocks of Catskill Formation; rare metamorphic rocks; boulders of gray sandstone up to 3 feet (1 m) in diameter are common, and are sometimes up to 6 feet (2 m) in diameter.

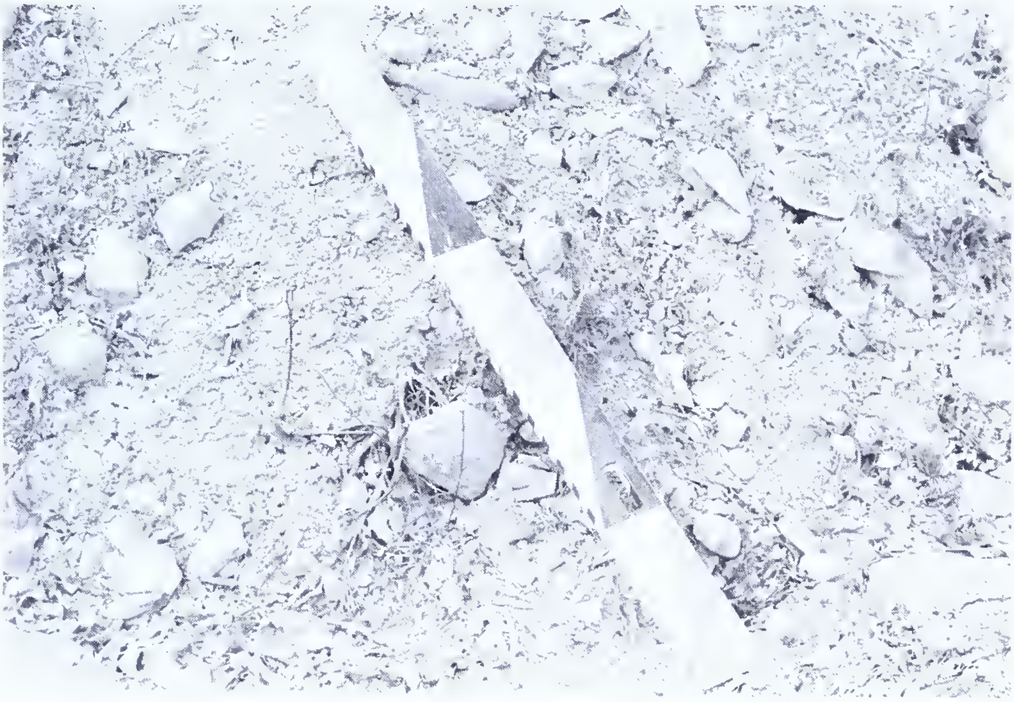

Figure 9. Exposure of Woodfordian till showing range of grain size and both rounded and angular cobbles. Exposure occurs in a road cutbank on the west side of Bear Town Road in the southwestern part of the area (41°09′48″N/75°13′26″W) (position 9 on Plate 1). Scale is 5 feet (1.5 m) long.

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[1] Color designations are from Munsell Color Company (1971).

GEOMORPHOLOGY: Relatively smooth topography with minor development of swells and swales in flatter areas; main concentrations in bottoms and on lower sides of valleys; tonal and textural differences between surfaces underlain by bedrock and till are generally readily apparent on good aerial photographs; scattered boulders occur on ground-moraine surface; no clearly established drainage pattern is developed on till, but regional drainage pattern is generally bedrock controlled; supports thick deciduous forest and dense undergrowth dominated by fern, rhododendron, and laurel.

EXPOSURES: Only temporary exposures of ground moraine are available; these occur in many roadside ditches, foundation excavations, or other active construction sites.

MINERAL RESOURCES: Useful as artificial fill, but with limitations due to large boulders; areally widespread, but generally thin.

ENGINEERING CHARACTERISTICS: Easy to moderately easy to excavate with some problems due to occasional large boulders; heterogeneous and bouldery nature may present minor drilling difficulties; maintains gentle to moderate cut slopes, but there is some potential instability on north-facing slopes that have groundwater seepage; fair to poor foundation for heavy structures; generally suitable for small impoundments, particularly in more clayey parts of till; difficulty with septic systems is possible because of variable permeability; suitable for sanitary landfill sites only if located in large deposits at a safe distance from the contact with permeable bedrock or other surficial units.

GROUNDWATER: Water table is generally located in underlying bedrock below base of ground moraine; generally too thin to be potential aquifer. Ground moraine sometimes thin enough to allow bedrock fracture traces to show on aerial photographs, providing good means of locating wells in underlying bedrock.

ORIGIN: Deposited beneath continental ice sheet during glacial advance as compact lodgement till, or left as less compact and sandy ablation till during ice melting and regional deglaciation.

GENERAL COMMENTS: Woodfordian age assignment is based on work of Crowl (1971), Sevon (1974), and Sevon and others (1975).

## GOULDSBORO END MORAINE

THICKNESS: Estimated to be more than 40 feet (12 m) thick in most places; two water well records near intersection of Snow Hill Road and Stony Run indicate thicknesses of 148 feet (45 m) and 40 feet (12 m).

LITHOLOGIC DESCRIPTION: Mainly till with some stratified sand and gravel; covers about 8 percent of area (4.5 square miles, or 11.7 km$^2$). *Till:* unsorted mixture of clay, silt, sand, pebbles, cobbles, and boulders up to 6 feet (2 m) in diameter; reddish brown to brown; generally sandy mixture with small to moderate amount of clay and moderate to large amount of material coarser than 3 inches (7.6 cm) in diameter; combined silt and clay content is generally less than 35 percent of till; fresh till is generally cohesive at depth and somewhat more friable near surface; pebbles and cobbles are mainly unweathered angular to subrounded gray sandstone derived from the Catskill Formation; contains small to moderate quantities of pebbles of red sandstone or siltstone derived from the Catskill Formation; igneous and metamorphic rock fragments are rare; striated pebbles are common. *Sand and gravel:* moderately well to well-sorted, stratified layers of sand and gravel; layers are less than 1 inch (2.5 cm) to several feet (over a meter) thick and are commonly inclined or cross stratified; lithologic composition is the same as for till; materials coarser than sand are generally subrounded to rounded. Till is not differentiated from the sand and gravel on the map (Plate 1).

GEOMORPHOLOGY: Zone of irregular topography with small rounded hills and some undrained depressions; local relief is generally in the range of 10 to 30 feet (3 to 9 m); generally well vegetated with mixed deciduous forest and thick undergrowth; occurs mainly as discontinuous valley fill in southern part of area; lacks integrated drainage in some areas and has some swampy conditions; topography is best seen in area of Easton Anglers (41°10′30″N/75°09′40″W) and along Snow Hill Road northwest of Camp Girard (41°09′24″N/75°09′42″W).

EXPOSURES: No good exposures; small exposures along roads and in temporary excavations.

MINERAL RESOURCES: Till is moderately useful for random fill but has some limitations because of low clay content and occasional boulders. Sand and gravel is generally well suited for most aggregates unless red siltstone or shale content is high; sizing is required, and more than normal washing and crushing may be required in some cases; lateral continuity of individual deposits is variable and sporadic; resources should be proven prior to development; available quantity of sand and gravel is not known.

ENGINEERING CHARACTERISTICS: Easy to excavate; maintains gentle cut slopes, with potential for slumping on north-facing slopes that have groundwater seepage; rapid drilling rate except where boulders are encountered; fair to poor foundation for heavy structures; moderate suitability for pond or artificial lake construction, but clay liner may be required; generally unsuitable for sanitary landfills, surface solid waste disposal, and sewage lagoons because of locally moderate to high permeability rate, variable slopes, and local variation of groundwater table; marginally suitable for septic systems, but clay lenses or zones are common problems.

GROUNDWATER: Groundwater table sometimes intersects surface in undrained depressions and maintains swampy conditions; no known production of groundwater; potential probably low.

ORIGIN: Complex of till and sand and gravel was deposited by Woodfordian glacier during period of deglaciation following maximum southward ice advance about 15,000 ybp (years before present); materials formed by ice shove, mudflow off ice, and melting of ice with fluvial transport off ice.

GENERAL COMMENTS: Part of morainic system is defined to the west in the Tobyhanna and Buck Hill Falls quadrangles (Sevon, 1975a).

## WOODFORDIAN ICE-CONTACT STRATIFIED DRIFT

THICKNESS: Variable; larger deposits may exceed 50 feet (15 m) in thickness, but most deposits are probably thinner; maximum exposed thickness is about 30 feet (9 m) north of Dancing Ridge (41°10′18″N/75°10′30″W).

LITHOLOGIC DESCRIPTION: Covers about 1 percent of area (0.7 square mile, or 1.8 km$^2$). Stratified sand and gravel, commonly containing boulders up to 3 feet (1 m) long; boulders up to 8 feet (2 m) long were observed. Sample from small borrow pit along Snow Hill Road north of Camp Girard (41°09′20″N/75°08′50″W) indicates that for particles larger than ¼ inch (0.6 cm) in diameter: 76 percent (by weight) are fine-grained gray sandstone, 11 percent are gray siltstone and claystone, 13 percent are red siltstone and claystone, and there are traces of conglomeratic sandstone, calcareous breccia, and medium-grained gray sandstone; materials coarser than 1 inch (2.5 cm) in diameter are generally gray sandstone; sand-sized material 1 mm and larger is mainly rock fragments (80 percent gray siltstones and remainder red siltstones); the amount of quartz increases with decreasing size and makes up 90 percent or more of sand finer than 0.15 mm; material observed in other deposits appears similar in composition. Stratified sands and gravels have abrupt and numerous lateral and vertical changes in texture; some sandy till is included within sand and gravel or at top of deposit; average pebble size is variable from deposit to deposit but is frequently between 1 and 2 inches (2.5 and 5 cm).

GEOMORPHOLOGY: Occurs mainly as deposits with irregular, hummocky topography and low relief along valley bottom of Bush Kill in northeastern part of area, north of Gouldsboro end moraine; two elongate ridges (eskers) occur within Gouldsboro end moraine at 41°10′18″N/75°10′30″W (north of Dancing Ridge) (Figure 10) and 41°09′18″N/75°12′12″W (southwest of Snow Hill).

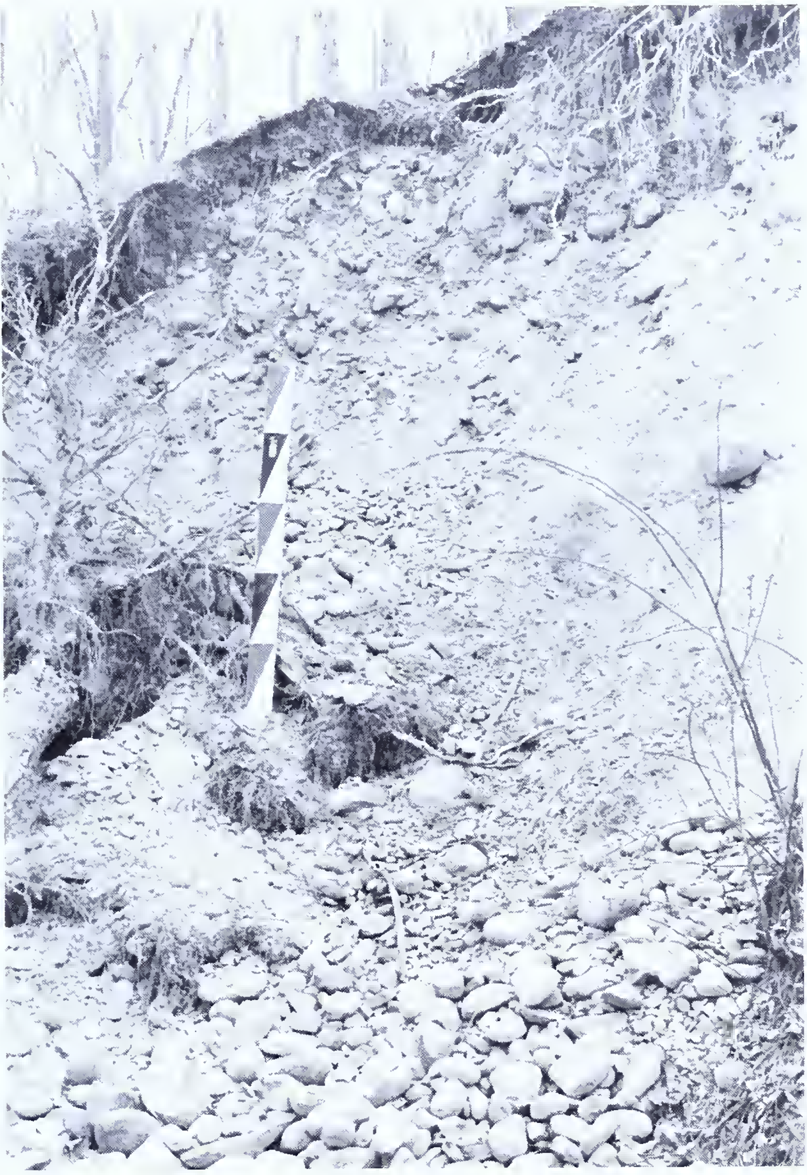

Figure 10. Poorly stratified sand and cobbles exposed in a small borrow pit opened in the Woodfordian ice-contact stratified drift of an esker located in the central part of the area (41°10′18″N/75°10′30″W) (position 10 on Plate 1). Scale is 5 feet (1.5 m) long.

EXPOSURES: Good exposures in borrow pits at 41°09′20″N/75°08′50″W (near Camp Girard), 41°10′18″N/75°10′30″W (north of Dancing Ridge), 41°09′18″N/75°12′12″W (southwest of Snow Hill), and 41°08′45″N/-75°09′27″W (southwest of Camp Girard).

MINERAL RESOURCES: Suitable as source of coarse and fine aggregate; will require routine crushing, washing, and sizing; generally no groundwater problems during excavation because of position above water table; composition is generally suitable for good-quality aggregate (see "Lithologic Description").

ENGINEERING CHARACTERISTICS: Easy to excavate; rapid drilling rates, except when sandstone blocks or boulders are encountered; maintains only gentle cut slopes, with considerable potential for slumping and sliding during excavation; not suitable for impoundments; marginally suitable for domestic septic systems because of high permeability; unsuitable for sanitary landfill sites or surface solid waste disposal; unsuitable to poor foundation for heavy structures.

GROUNDWATER: Ice-contact stratified-drift deposits are located, in general, above the static water table and are not suitable as a source of groundwater; wells are normally driven into bedrock; heavy-duty casing in ice-contact deposits is probably necessary in situations where shifting of materials is a potential hazard.

ORIGIN: Woodfordian ice-contact stratified drift was deposited during stagnation and melting phase of Woodfordian ice sheet; limited mostly to ice-filled valleys behind Gouldsboro end moraine; some material was deposited beneath ice sheet as eskers; deglaciation and deposition of stratified drift was strongly influenced by preglacial topography and drainage pattern.

## BOULDER COLLUVIUM

THICKNESS: Variable and largely unknown; single layer of boulders at margin of deposit; probably exceeds 6 feet (2 m) in center of larger deposits.

LITHOLOGIC DESCRIPTION: Covers 0.5 percent of area (0.3 square mile, or 0.8 km$^2$). Angular to rounded boulders from a few inches to several feet in diameter or length (Figures 11 and 12); generally poorly sorted; tightly to loosely packed; sand or mud matrix; common open interstices, particularly in center of deposit; some deciduous vegetation but little or no undergrowth.

GEOMORPHOLOGY: Occurs mainly in long, narrow deposits below sandstone rock ledges in eastern half of area; some occurrence in small intermittent stream valleys; mainly overlies bedrock, but sometimes overlies Woodfordian ground moraine; surface is relatively flat but irregular because of boulders; slope of surface is variable but frequently moderately steep, conforming to general land-surface slope in area surrounding deposit.

EXPOSURES: No known excavations in boulder colluvium; most readily accessible deposit occurs north of Snow Hill Road near fire tower on Dancing Ridge (41°09′48″N/75°10′06″W).

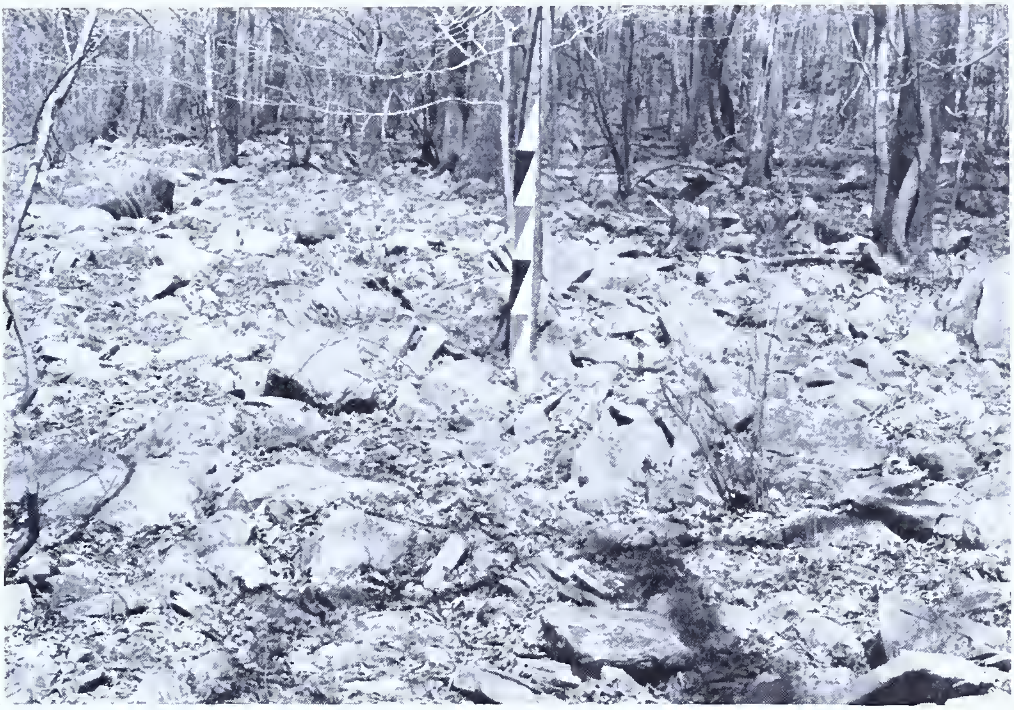

Figure 11. Boulder colluvium developed on a relatively flat surface in the valley bottom of Leavitt Branch in the northwestern part of the area (41°14′17″N/75°13′48″W) (position 11 on Plate 1). Deposit is typical of many in the mapped area. Scale is 5 feet (1.5 m) long.

MINERAL RESOURCES: No known utilization; limited potential for riprap.

ENGINEERING CHARACTERISTICS: Moderately easy to excavate; maintains gentle to moderate slopes, with some potential for rockslides when undercut on steeper slopes; unsuitable for any waste disposal or impoundments because of slope, thickness of deposit, and open framework; poor to only fair foundation for heavy structures, depending on slope and underlying material (bedrock is more stable than till). Land use problems are related to slope and uneven, rocky ground.

GROUNDWATER: No known production or potential as source of groundwater.

ORIGIN: Boulders were derived from sandstone bedrock ledges by freeze-thaw breakage, or from till by frost-heave concentration; mixed with soil and moved downslope by gravity; formed primarily during periglacial climate accompanying regional deglaciation.

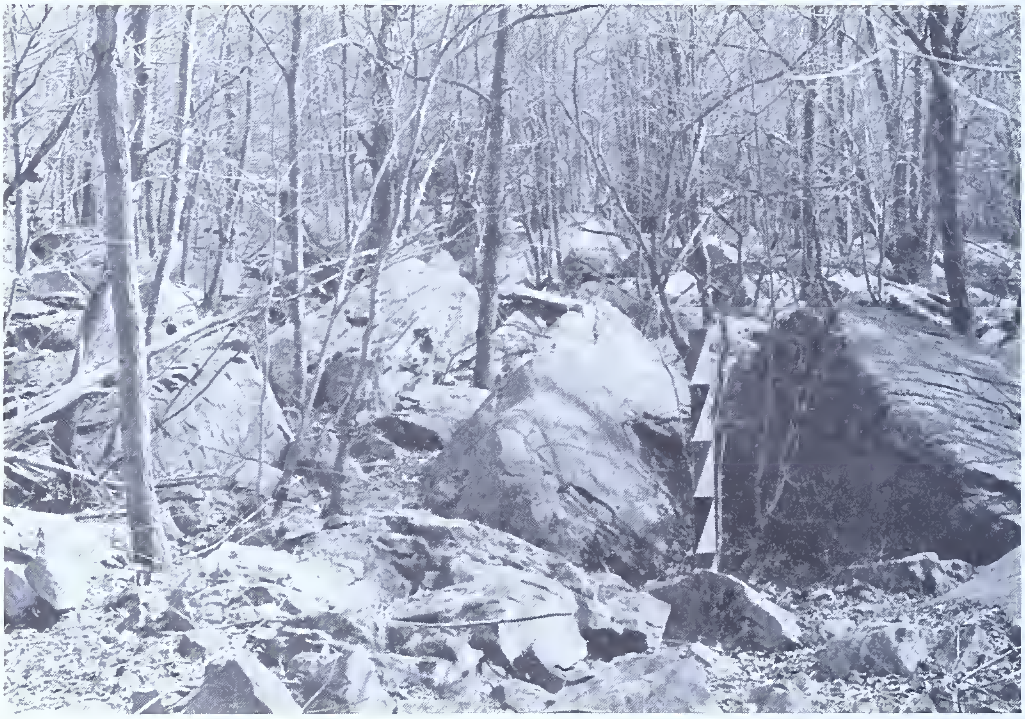

Figure 12. Boulder colluvium developed on a relatively flat surface below a rock outcrop in the valley of Leavitt Branch in the northwestern part of the area (41°15′00″N/75°14′02″W) (position 12 on Plate 1). Deposit contains exceptionally large blocks, and displays extreme in size range for boulder colluvium. Scale divided in feet (0.3 m).

## ALLUVIUM AND WOODFORDIAN OUTWASH, UNDIFFERENTIATED

THICKNESS: Unknown from direct data; probably variable and less than 10 feet (3 m) in most places, but may be thicker along parts of Brodhead Creek and in the headwaters of Mud Run just west of Dancing Ridge.

LITHOLOGIC DESCRIPTION: Covers 2 percent of area (1.2 square mile, or 3.1 $km^2$); dominantly unconsolidated sand and gravel, generally with less than 20 percent silt and clay; percent of gravel and sand is variable, but there is usually more gravel than sand; generally occurs in well-stratified beds with moderate to good size-sorting; contains some boulders up to 2 feet (0.6 m) in diameter; deposit in headwaters of Mud Run just west of Dancing Ridge is coarser than most other deposits; gravel is rounded to well rounded; pebble lithology is dominantly gray sandstone derived from Catskill Formation; overall composition is similar to that of Woodfordian ice-contact stratified drift, but with less red and gray siltstone and claystone.

GEOMORPHOLOGY: Flat-surfaced deposit mainly filling valley bottoms of Bush Kill, Brodhead Creek, Stony Run, Leavitt Branch, and the small valley at the headwaters of Mud Run just west of Dancing Ridge; generally well-defined slope change at margin of deposit, but some slope gradation into adjacent Woodfordian ice-contact stratified drift deposits along Bush Kill and at head of Mud Run; currently being eroded by streams, which have cut channels several feet deep in some deposits and are subject to periodic flooding with consequent deposition of eroded materials (Figure 13) (except for deposit at head of Mud Run).

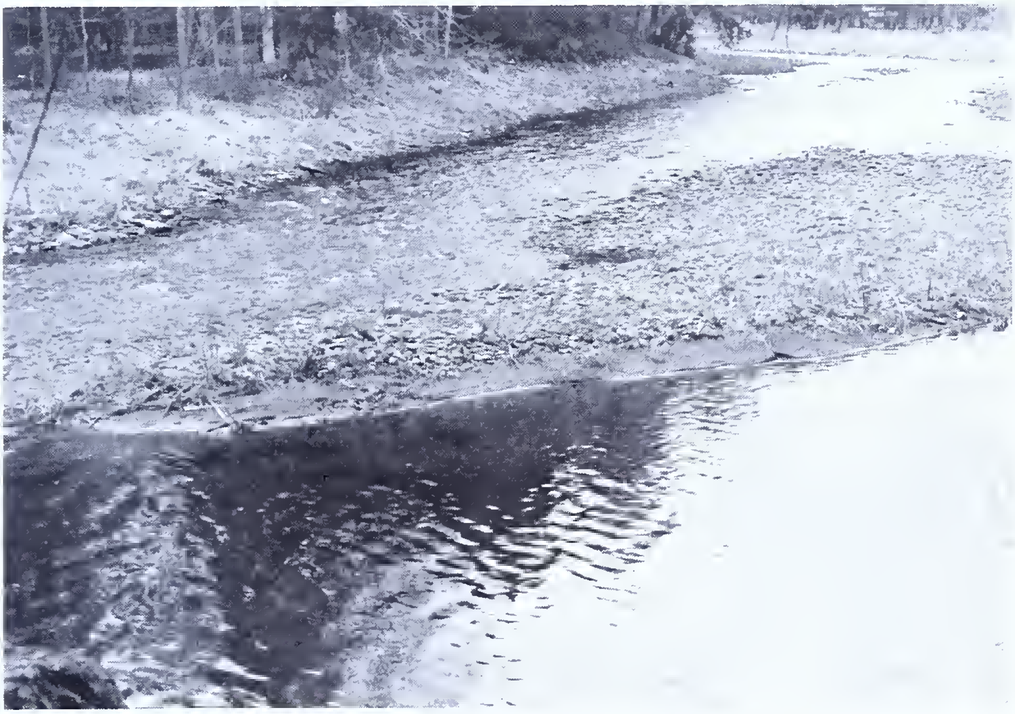

Figure 13. Surface of undifferentiated alluvium and Woodfordian outwash exposed in Brodhead Creek just east of Pa. Route 447 in the west-central part of the area (41°10′24″N/-75°14′46″W) (position 13 on Plate 1). Original surface (under vegetation at left rear of picture) has been incised over 4 feet (1.2 m) by Brodhead Creek. Gravel bar in foreground comprises redeposited sands and gravels eroded from upstream.

EXPOSURES: Temporary exposures along stream margins and in rare temporary excavations; some pits in deposit at head of Mud Run.

MINERAL RESOURCES: Potential as source of coarse and fine aggregate is limited because of probable thinness of deposits and problem of high groundwater table.

ENGINEERING CHARACTERISTICS: Easy to excavate; rapid drilling rate with minor difficulty due to large boulders; maintains only very gentle cut slopes; unsuitable to fair foundation for heavy structures, with minor potential for buried, compressible humic soils; fair impoundment suitability because of high groundwater table; subject to occasional flooding; unsuitable for septic systems and waste disposal sites because of high groundwater table and flooding.

GROUNDWATER: Very low potential for groundwater supply because of limited size and thickness of deposit; closeness of groundwater table to surface and rapid permeability increase potential for contamination of wells from upstream sources.

ORIGIN: Initially deposited by melting Woodfordian glacier; upper surface reworked by action of modern streams, with erosion and redeposition of older material.

## PEAT

THICKNESS: Variable; all deposits are generally thicker in center and thinner at margins; smaller deposits are probably 10 feet (3 m) thick or less, whereas larger deposits may be as thick as 30 feet (9 m).

LITHOLOGIC DESCRIPTION: Covers 2.3 percent of area (1.3 square mile, or 3.4 km$^2$). Composed of decayed sedges, reeds, rushes, mosses, shrubs, and trees; upper part is often black peat humus (peat disintegrated into finely divided particles); peat is generally fibrous and woody and light to dark brown when dry; water-saturated in natural state; sometimes underlain by bluish clay and silt; deposits are frequently surrounded by bouldery margin.

GEOMORPHOLOGY: Occurs in level, undrained or poorly drained, swampy areas in natural lowland and upland depressions (Figure 14); some deposits are overgrown with black spruce, hemlock, birch, white pine, alder, and high-bush blueberry; some deposits have grass, sedge, and sparse shrubs in center and higher vegetation near margins only; water table is at or near surface.

EXPOSURES: Only the surface of peat bogs is exposed in most places; some peat is intermittently exposed in a commercial harvest area immediately north of mapped area in Promised Land quadrangle, at north end of Goose Pond (41°15′00″N/75°11′59″W).

MINERAL RESOURCES: Major use is for general soil improvement; operations involve bog drainage, peat harvesting, drying, shredding, screening (Figure 15), weighing, and packaging; see Cameron (1970) and Edgerton (1969) for further information.

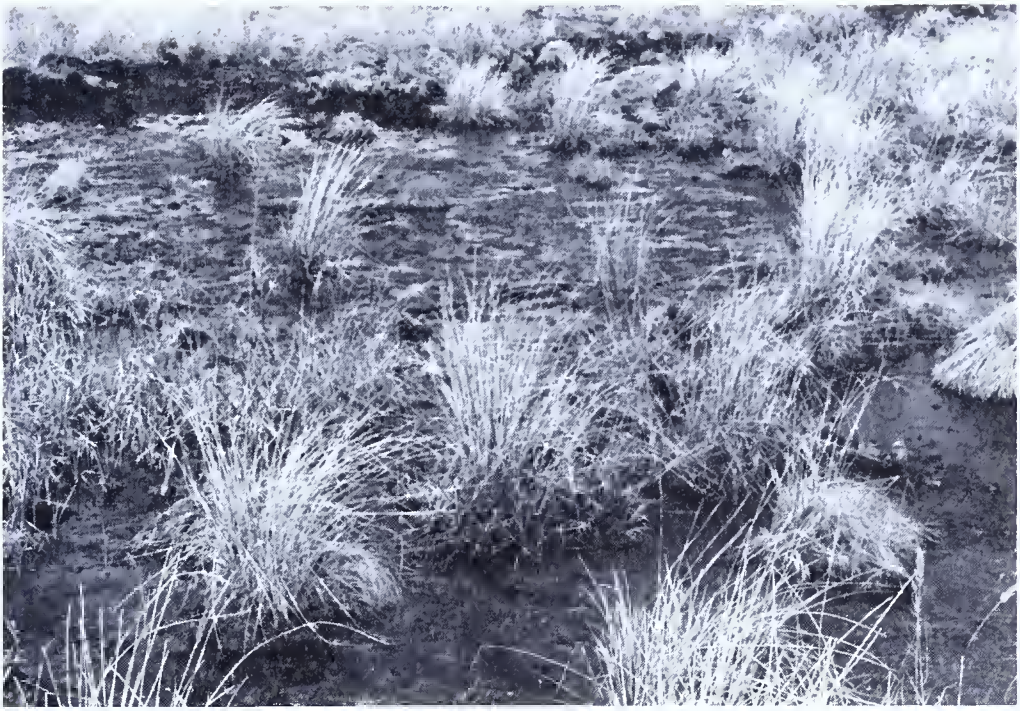

Figure 14. Swampy surface of typical peat bog with grass vegetation and water-saturated peat, occurring at the north end of Goose Pond immediately north of the mapped area in the Promised Land quadrangle (41°15′00″N/75°11′59″W) (position 14 on Plate 1).

ENGINEERING CHARACTERISTICS: Unsuitable for any structures because of water saturation, compactability, and lack of bearing strength; easily excavated by drag line when wet, and front end loader when dry; must be removed or displaced by fill where crossed by roads; subject to flooding; unsuitable for any type of waste disposal.

GROUNDWATER: Saturated with water unless artificially drained, but poor source because of uncertainty of replenishment, high coliform bacteria content, and turbidity; surface water is contaminated by tannic acid.

ORIGIN: Product of partial decay of sedges, reeds, rushes, mosses, shrubs, and trees below water level in depressions created by Woodfordian glaciation.

## MUCK

THICKNESS: Variable; seldom more than 5 feet (2 m).

LITHOLOGIC DESCRIPTION: Covers 0.5 percent of area (0.3 square mile, or 0.8 km$^2$). Finely disaggregated and partly decomposed organic debris mixed with some silt and clay; black color; commonly has scattered boulders at or near

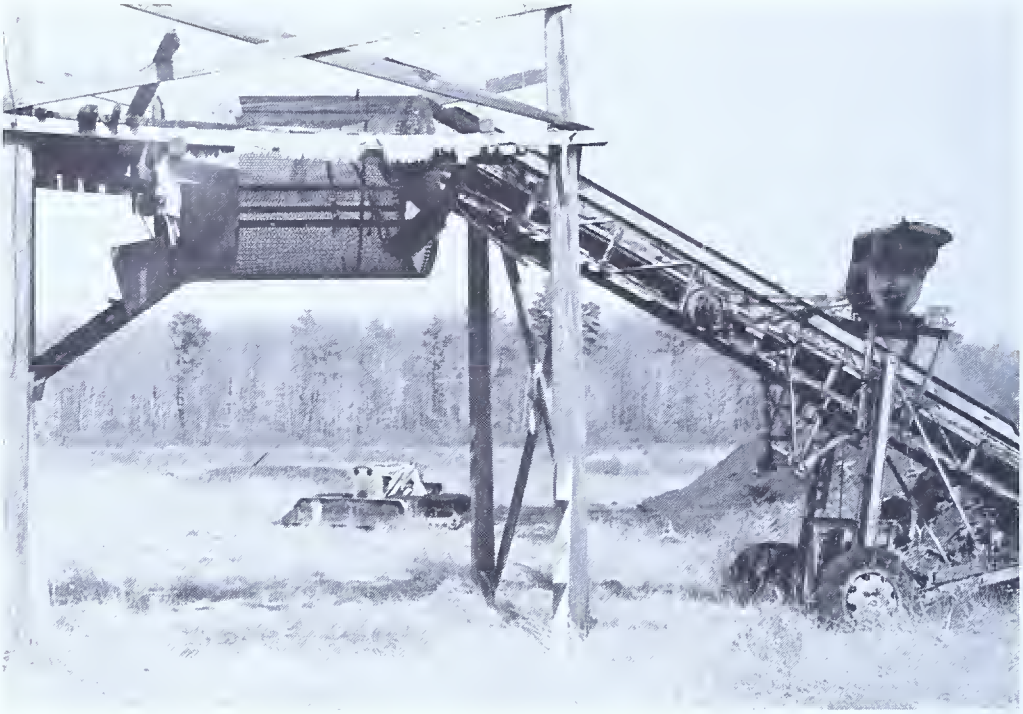

Figure 15. Screen used to sift dried peat at formerly operational harvesting site at the north end of Goose Pond immediately north of the mapped area in the Promised Land quadrangle (41°15′00″N/75°11′59″W) (position 15 on Plate 1). Harvested peat mounded in a drying pile occurs in the background to the right of the bulldozer used in the harvesting operation. Scale is 5 feet (1.5 m) long.

surface; contains some logs and other woody material, particularly at bottom of deposit.

GEOMORPHOLOGY: Forms in shallow, undrained or poorly drained depressions occurring mainly on Woodfordian ground moraine; usually well vegetated with deciduous forest and shrub undergrowth; small mounds of low vegetation and some boulders protrude from standing or very slowly moving water; a swampy area with low organic accumulation rate.

EXPOSURES: No known cuts into these deposits; surfaces are easily examined at any of the mapped deposits.

MINERAL RESOURCES: Not developed as a mineral resource, but has limited potential as soil for some crops if cleared, drained, and managed properly.

ENGINEERING CHARACTERISTICS: Easy to excavate; unsuitable foundation for heavy structures; compressible; some impoundment suitability; unsuitable for any waste disposal; subject to periodic flooding.

GROUNDWATER: No potential as source of groundwater because of shallowness of deposit, high coliform bacteria content, and tannic acid.

ORIGIN: Similar to peat but with intermittent deposition of silt and clay; slow and minor accumulation and decomposition of organic material below water surface in shallow depressions with slowly through flowing water developed on Woodfordian ground moraine.

## ALLUVIUM AND COLLUVIUM, UNDIFFERENTIATED

THICKNESS: Variable; generally less than 6 feet (2 m) thick, although deposit at mouth of Lucky Run (41°09′24″N/75°13′57″W) may be thicker.

LITHOLOGIC DESCRIPTION: Covers 0.2 percent of area (0.1 square mile, or 0.26 km$^2$). Comprises till mixed with local bedrock debris and some fluvial gravel. Basically unsorted mixture of clay, silt, sand, gravel, and boulders with low cohesion and sandy texture; generally includes numerous boulders of gray sandstone up to 4 feet (1 m) in diameter; surface may have intermittent stream along which moderately sorted sand and gravel occurs; surface is frequently bouldery.

GEOMORPHOLOGY: Occurs as irregular to relatively smooth surfaced deposit in narrow valleys having low to moderate gradient and generally lacking perennial streams; moderately to thickly vegetated with deciduous forest and undergrowth.

EXPOSURES: No known exposures of material; surface character is displayed at all deposits.

MINERAL RESOURCES: No known resource potential.

ENGINEERING CHARACTERISTICS: Easy to moderately easy to excavate, depending partly on size and concentration of boulders; maintains only gentle cut slopes; rapid drilling rate except for boulders; unsuitable to poor foundation for heavy structures; unsuitable for impoundments and any waste disposal because of slope and moderately free movement of groundwater.

GROUNDWATER: No potential as source of groundwater because of size of deposits, possibility of near surface contamination, and uncertainty of recharge.

ORIGIN: Result of gravity movement of Woodfordian ground moraine down slopes onto valley bottoms with subsequent surface modification by intermittent streams. Probably formed partly during emplacement of Gouldsboro end moraine.

## ALLUVIAL FAN

THICKNESS: Variable; zero thickness at end of deposit; maximum of 15 to 25 feet (5 to 8 m) at lower center part of deposit.

LITHOLOGIC DESCRIPTION: Unsorted to moderately well sorted, jumbled mixture of clay, silt, sand, gravel, and boulders; derived from glacial till; composition of fan resembles that of till except for greater number of boulders and better sorting; generally has moderate to high porosity and permeability.

GEOMORPHOLOGY: Fan shape with apex at upslope end of deposit; rounded, convex surface, with center higher than margins; a channel has been cut into the surface by a stream.

EXPOSURES: Limited exposure along stream cut; the only mapped alluvial fan occurs on the east side of Bush Kill at 41°11′15″N/75°09′39″W.

MINERAL RESOURCES: Limited potential as source of sand and gravel.

ENGINEERING CHARACTERISTICS: Moderately easy to excavate; moderate drilling rate; maintains only very gentle cut slope; poor foundation for heavy structures; unsuitable for impoundments and all waste disposal because of slope, permeability, and flood potential.

GROUNDWATER: No potential as source of groundwater because of small size of deposit.

ORIGIN: Developed as debris deposit at junction of steep-sloped valley with broad, flat valley; result of change in ability of flooding stream to transport material.

## ARTIFICIAL FILL

THICKNESS: A few feet to several tens of feet (several meters) thick; mapped where greater than 3 feet (1 m) thick and where observable as a distinct feature on aerial photographs at scale 1:24,000.

LITHOLOGIC DESCRIPTION: Covers 0.04 percent of area (0.02 square mile, or 0.05 km$^2$). Mixture of angular rock fragments and soil or till; generally compacted by heavy equipment; sometimes partly concrete.

GEOMORPHOLOGY: Occurs as fill across drainages for leveling or raising elevation of roadways; occurs as dams for lakes; frequently vegetated with grass or crown vetch; sometimes covered with rock (riprap) on dams.

EXPOSURES: Generally covered, with no exposure of material.

ENGINEERING CHARACTERISTICS: Moderately easy to excavate; moderate drilling rate; good slope stability unless local alteration of groundwater table results in water seepage into deposit; subject to erosion and extensive gullying if not protected by vegetation or riprap; unsuitable for any waste disposal.

GROUNDWATER: No groundwater potential.

# STRUCTURAL GEOLOGY

The structure of the Upper Devonian rocks in the area is interpreted mainly from exposures in the western part of the area. An interpretation of the structure is shown in cross section A-A′ (Plate 1).

## FOLDS

Several third-order folds (wavelengths from a few hundreds of feet to a half mile (0.8 km) (Nickelsen, 1973)) have axes which plunge generally S69W at 2° (Figure 16). The fold axes are seldom exposed, but one axis that is exposed north of Snow Hill Road at 41°09′07″N/75°13′42″W, and observations in adjacent areas of Monroe and Pike Counties, indicate that these folds have planar limbs and narrow hinges. This geometry suggests a kink-band style of folding such as that described by Faill (1973). The abundance of surficial cover in the area prevents determination of the lateral continuity of these folds. The apparent excessive thickness of the Long Run Member of the Catskill Formation calculated from cross section A-A′ (Plate 1) probably results from several undetected fold axes.

## FRACTURES

Sets of fractures occur in the rocks throughout the area, and an equal-area stereonet plot of the pole projections of these fractures is shown in Figure 16. The fractures are classified as either joints or cleavage.

### Joints

Figure 16 and field data indicate the following about the joints:

1. The primary joint set has an average strike of N2E (± 6°) and dips generally between 85° east and vertical. These joints occur as smooth planes, generally spaced between 5 and 10 feet (1.5 and 3 m) apart. They are generally open at the surface and form the faces of numerous sandstone ledges. Nothing is known of their maximum subsurface extent or openness at depth.
2. Two secondary joint sets have more easterly orientations and are nearly gradational from one to the other. They strike N17E (± 4°) and N30E (± 8°)

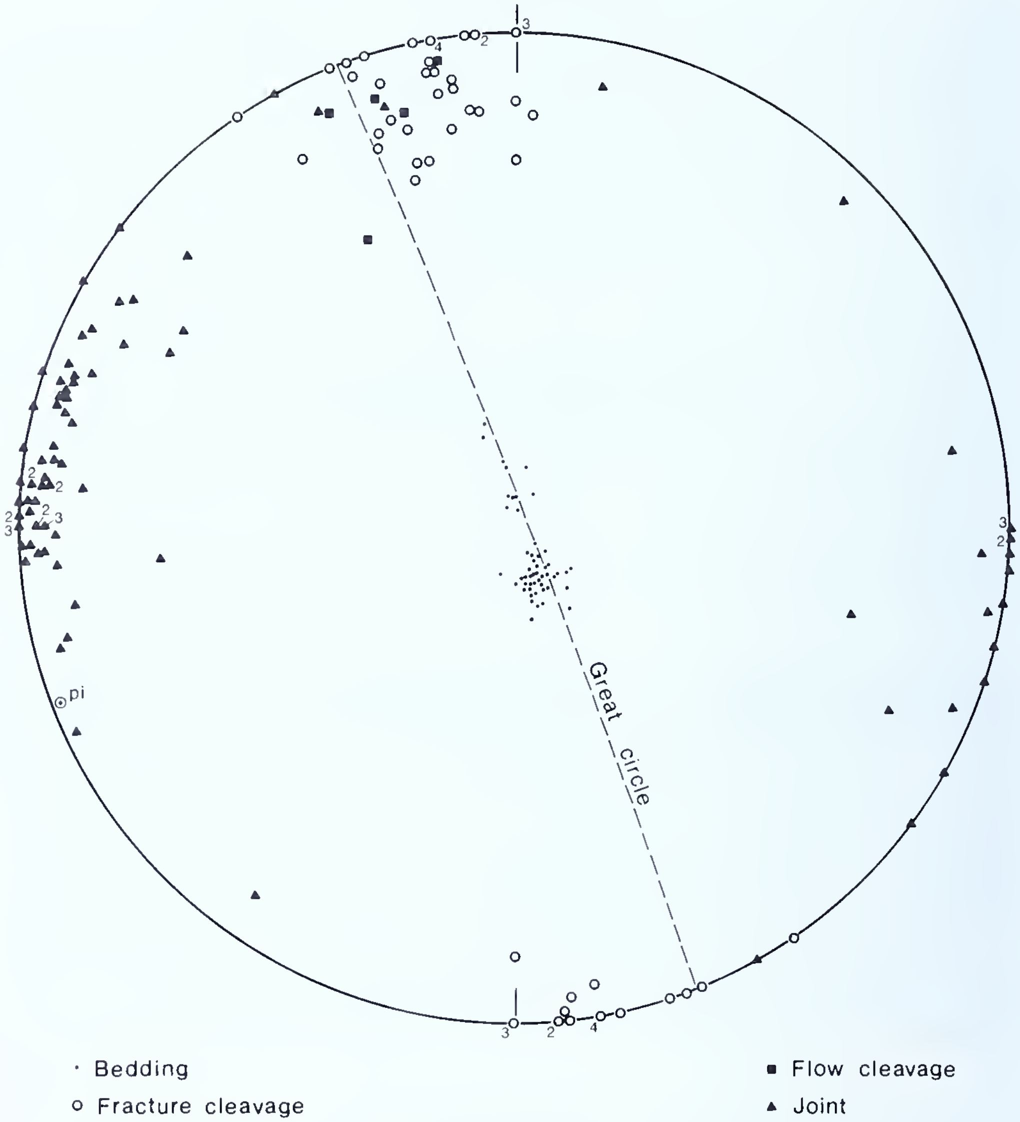

Figure 16. Equal-area lower hemisphere projection of poles to bedding, jointing, fracture cleavage, and flow cleavage in the Catskill Formation in the Skytop quadrangle. Observations include 50 of bedding, 76 of jointing, 40 of fracture cleavage, and 5 of flow cleavage. Numbers by symbols indicate number of observations where more than one. The great-circle position defines the average fold-axis orientation (pi) for the report area.

and have dips between 82° and 86° east, and 74° east and vertical, respectively. These joints also occur as smooth planes and are open at the surface. Although spacing of these joints is variable, it tends to average between 2 and 5 feet (0.6 and 1.5 m).

3. The other major joint set is recognized as fracture cleavage and strikes N80E (± 10°); dips vary between 72° east and vertical, but most dips are steeper than 80° east. These fractures are irregular, undulatory surfaces and have an average spacing between 2 and 4 inches (5 and 10 cm). Fracture cleavage is generally open at the surface and contributes significantly to the physical disintegration of bedrock. These fractures are genetically related to flow cleavage; they sometimes grade into probable flow cleavage formed in some shales of the report area.

A typical bedding surface showing abundant joints is illustrated in Figure 17. Intersecting joints are well shown in Figure 3, and a joint forming the south side of a sandstone ledge is shown in Figure 7.

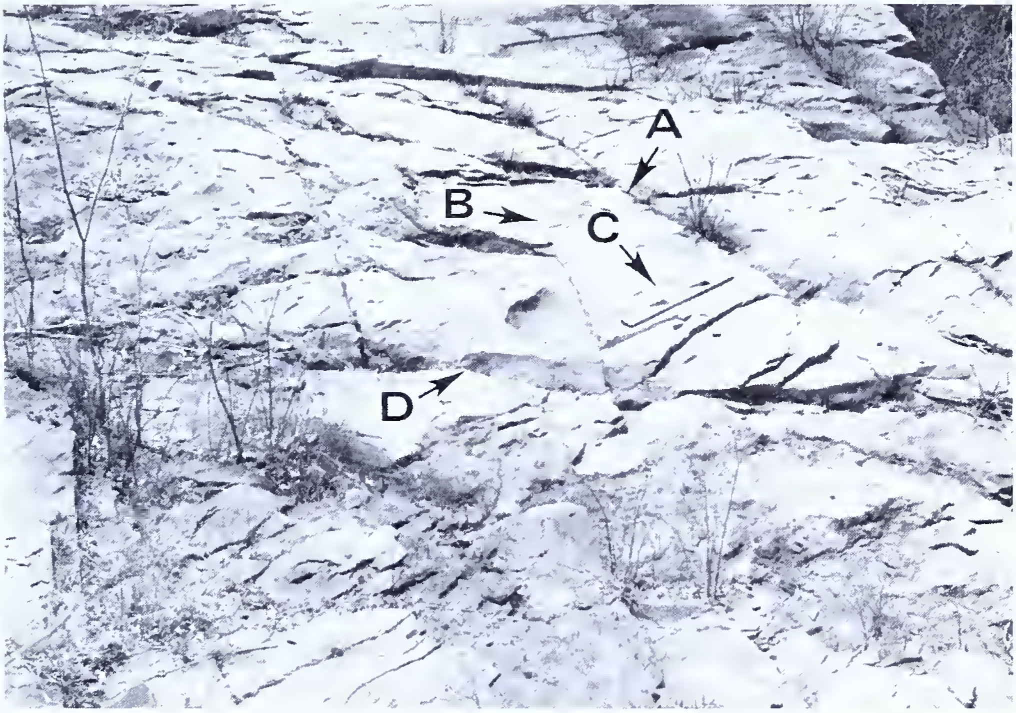

Figure 17. Bedding surface of gray sandstone of the Long Run Member of the Catskill Formation showing abundant joints having different orientations. Outcrop occurs at Leavitt Falls in the northwestern part of the area (41°13′23″N/75°14′26″W) (position 17 on Plate 1). Scale is 5 feet (1.5 m) long. Fracture data are: A—N3E/85E with 5- to 8-foot (1.5- to 2.4-m) spacing (joint); B—N20E/82E with irregular spacing (joint); C—N72E/90 ± 5 with 3- to 6-inch (7.6- to 15.2-cm) spacing (fracture cleavage) parallel to scale; and D—N62W/75N with irregular spacing (joint).

## Cleavage

Flow cleavage is not proven to exist in this area, but five orientations of closely spaced fracturing interpreted as cleavage were obtained from exposed shales (Figure 16). These observations indicate a strike of N72E (± 8°) and a dip ranging between 76° and 82° south. This strike direction agrees well with fold-axis orientation of the area and implies a genetic relationship.

## FRACTURE TRACES

Numerous fracture traces (less than 1 mile (1.6 km) long) have been observed on aerial photographs of the area, and their traces are plotted on Plate 1. These fractures are subdivided into major (greater than ¼ mile (0.4 km) long) and minor (less than ¼ mile (0.4 km) long). A rose-diagram plot of 188 fracture traces (Figure 18) shows that about 53 percent of the traces have orientations between N10W-S10E and N40E-S40W and a median orientation of about N20E-S20W. The fracture traces are distributed uniformly throughout the area and appear to be related to the major joint systems that have orientations of N17E and N30E.

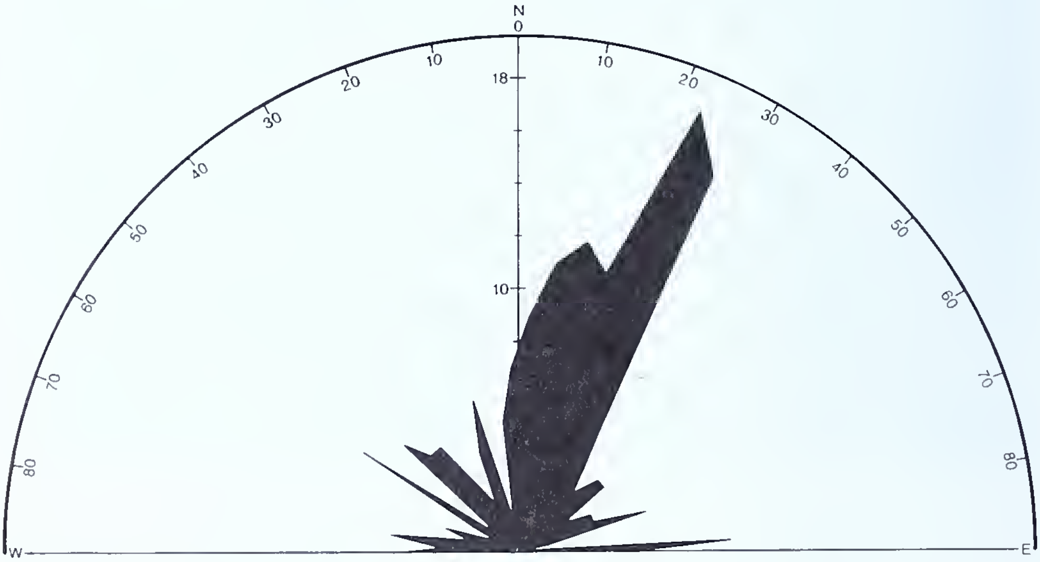

Figure 18. Rose diagram of 188 fracture traces recognized in the Skytop quadrangle. Numerals on ordinate represent number of observations.

## COMMENT

The fractures and fracture traces are a pervasive and predictable structural fabric throughout the area and contribute significantly to orientation of drainage and topography, occurrence of rock ledges, rock disintegration, and relative groundwater availability. Those engaged in engineering works and water well development should take these important planar elements into account early in planning.

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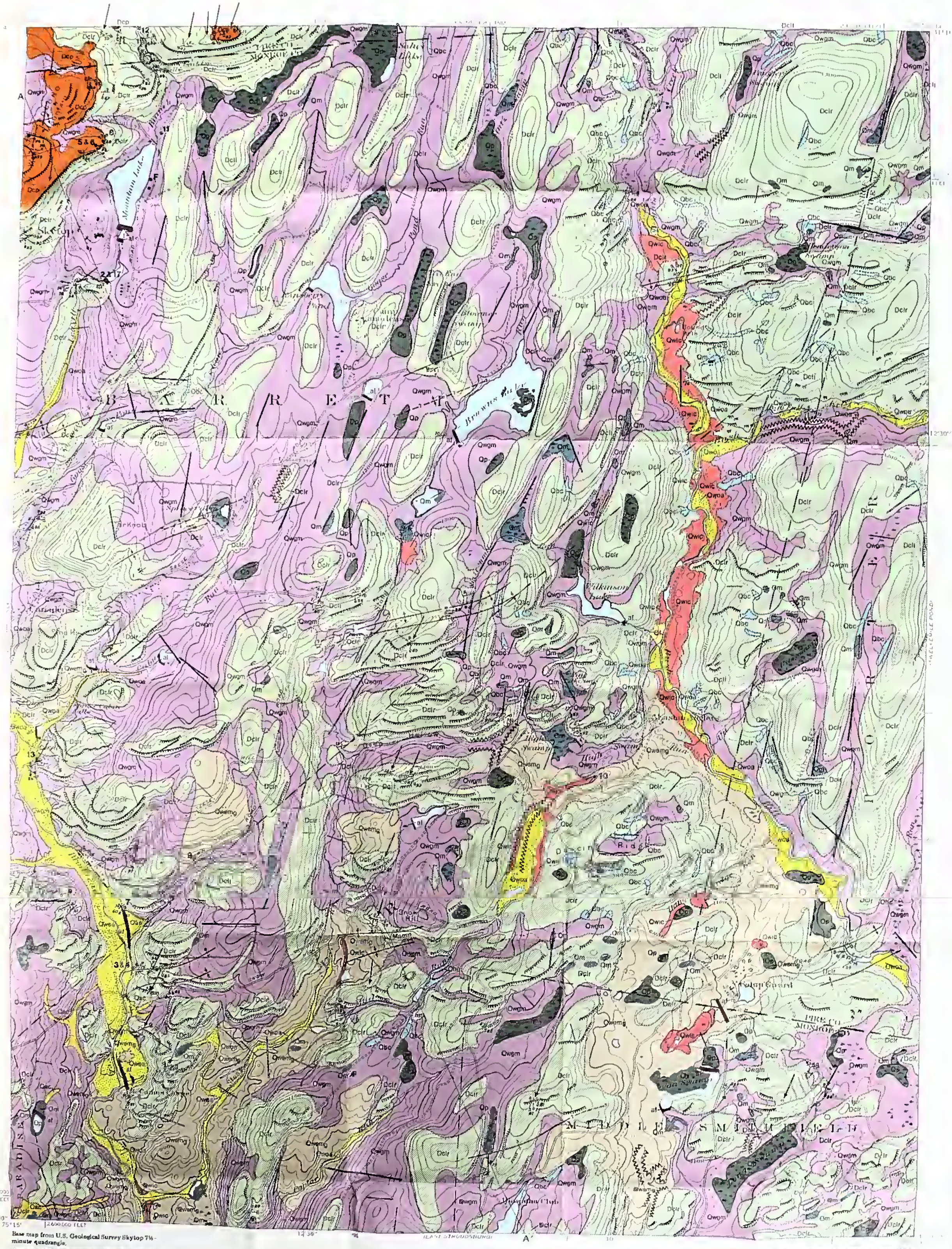
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

A 214a, Plate 1



Base map from U.S. Geological Survey Skytop 7½-minute quadrangle.

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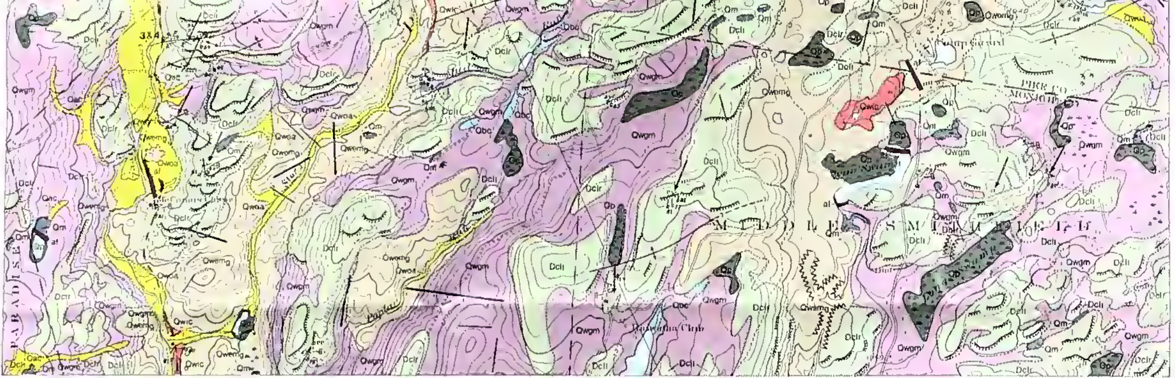
Geology based on field mapping during 1974

Virginia M. Milewski, Cartographer

## EXPLANATION

| | | GEOLOGIC DESCRIPTION | UNIT | ENVIRONMENTAL CHARACTERISTICS |
|---|---|---|---|---|
| HOLOCENE | | Mixture of rock fragments and soil or till; usually roadway fill or man-made dams; up to several tens of feet (several meters) thick. | **ARTIFICIAL FILL**<br>al | Not an aquifer.<br>Moderately easy to excavate, good slope stability; good foundation for heavy structures only where designed for them.<br>No mineral resources. |
| | | Unsorted to moderately well sorted mixture of clay, silt, sand, gravel, and boulders; fan-shaped deposit with apex at upslope end of deposit and rounded, convex surface; deposited at junction of steep-sloped valley with broad, flat valley; thickness varies from 0 to 25 feet (8 m). | **ALLUVIAL FAN**<br>Qf | Not a significant aquifer.<br>Moderately easy to excavate; maintain only very gentle cut slopes; poor foundation for heavy structures.<br>Limited potential as source of sand and gravel. |
| | | Till mixed with local bedrock debris and some fluvial gravel; occurs as smooth-surfaced deposit in narrow valleys having low to moderate gradient and lacking perennial streams; result of gravity movement of till downslope, with subsequent surface modification by streams; generally less than 6 feet (2 m) thick. | **ALLUVIUM AND COLLUVIUM, UNDIFFERENTIATED**<br>Qac | Not a potential aquifer.<br>Easy to moderately easy to excavate; maintains only gentle cut slopes, unsuitable to poor foundation for heavy structures.<br>No known mineral resource potential. |
| | | Organic debris mixed with some silt and clay; formed in shallow, poorly drained depressions on Woodfordian ground moraine; similar in origin to peat; usually less than 5 feet (2 m) thick. | **MUCK**<br>Qm | Not an aquifer.<br>Easy to excavate; unsuitable foundation for any structure; subject to periodic flooding.<br>Not developed as mineral resource, but some potential as material for soil improvement. |
| | | Decayed vegetation, usually water saturated; occurs in undrained or poorly drained, swampy areas in natural depressions; usually thickly vegetated; water table at or near surface; product of partial decay of vegetation below water level in depressions created by Woodfordian glaciation; larger deposits may be 30 feet (9 m) thick, with thickest development in center and thinning to margins. | **PEAT**<br>Qp | Water saturated, but poor source of groundwater because of bacteria, turbidity, and tannic acid.<br>Easy to excavate; subject to flooding, unsuitable for any structure because of lack of bearing strength.<br>Peat commonly used as material for general soil improvement. |
| | | Unconsolidated and stratified sand and gravel, usually with more gravel than sand; some small boulders; gravel dominantly gray sandstone, but contains some small red siltstone fragments; deposits are generally flat surfaced, fill valley bottoms, and have well-defined slope change at margins; currently being incised, but subject to some periodic flooding; initially deposited by melting Woodfordian glacier, but upper surface reworked by action of modern streams; variable thickness, but usually less than 10 feet (3 m). | **ALLUVIUM AND WOODFORDIAN OUTWASH, UNDIFFERENTIATED**<br>Qwoa | Very low potential for groundwater supply; possible contamination from upstream sources.<br>Easy to excavate; maintains only very gentle cut slopes; unsuitable to fair foundation for heavy structures; subject to occasional flooding.<br>Limited potential as source of coarse and fine aggregate. |
| PLEISTOCENE | | Poorly sorted and variably packed boulders in sand or mud matrix, commonly with open interstices; poorly vegetated in general; occurs mainly in long, narrow deposits below sandstone rock ledges, but some occurrence in small intermittent-stream valleys; generated by intense freeze-thaw conditions in periglacial climate accompanying regional deglaciation; probably exceeds 6 feet (2 m) in thickness in larger deposits. | **BOULDER COLLUVIUM**<br>Qbc | Not an aquifer.<br>Moderately easy to excavate; maintain gentle to moderate slopes with some potential for rockslides when disturbed; generally unstable foundation for heavy structures.<br>Limited potential for riprap. |
| | | Unconsolidated, stratified sand and gravel, commonly with boulders up to 8 feet (2 m) long; gray sandstone is the most common gravel component, but gravel also includes lesser amounts of gray siltstone and red siltstone and claystone, with traces of conglomeratic sandstone and calcareous breccia; characterized by numerous abrupt lateral and vertical textural changes; some pods of sandy till; occurs mainly as deposits with irregular, hummocky topography and low relief along valley of Bush Kill and in region of Gouldsboro end moraine; includes two eskers; deposited by meltwater during stagnation and melting phase of Woodfordian ice sheet; variable thickness; larger deposits possibly exceed 50 feet (15 m), but most deposits are probably thinner. | **WOODFORDIAN ICE-CONTACT STRATIFIED DRIFT**<br>Qwic | Generally unsuitable as source of groundwater.<br>Easy to excavate; maintain only gentle cut slopes; unsuitable to poor foundation for heavy structures.<br>Suitable as source of coarse and fine aggregate. |
| | | Mainly till with some stratified sand and gravel; unsorted mixture of clay, silt, sand, pebbles, cobbles, and boulders; reddish brown to brown; silt and clay content generally less than 35 percent; usually cohesive at depth, but somewhat more friable near surface; cobbles mainly unweathered gray sandstone derived from Catskill Formation, with small quantities of red sandstone or siltstone; zones of stratified sand and gravel show same lithologic composition as till, but are much better sorted; end moraine occurs as zone of irregular topography with small, rounded hills and many undrained depressions; local relief generally from 10 to 30 feet (3 to 9 m); lacks integrated drainage and has some swampy conditions; deposited by Woodfordian glacier during period of deglaciation; estimated at more than 40 feet (12 m) thick in most places. | **GOULDSBORO END MORAINE**<br>Qwemg | Very poor aquifer potential, no known production of groundwater.<br>Easy to excavate, maintain gentle cut slopes, with some potential for slumping; fair to poor foundation for heavy structures.<br>Till moderately useful as random fill; zones of stratified sand and gravel generally well sorted for aggregate, but areal distribution and thickness unknown. |
| | | Till; unsorted and nonstratified mixture of clay, silt, sand, pebbles, cobbles, and boulders; generally reddish brown to dark brown, sometimes with pale reddish tinge; generally less than 35 percent silt and clay; moderately cohesive, but sometimes sandy and loose in uppermost part of thicker accumulations; more clayey and cohesive in lower parts of thick accumulations; cobbles mainly unweathered, subrounded fragments derived from gray or red rocks of Catskill Formation; boulders of gray sandstone up to 7 feet (2 m) in diameter common; relatively smooth topography with minor development of swells and swales in flatter areas; scattered boulders on ground-moraine surface; no clearly established drainage pattern; deposited as compact lodgement till or as less compact and sandy ablation till during ice melting and regional deglaciation; widely variable [illegible] m), with average thickness of 33 feet (10 m). | **WOODFORDIAN GROUND MORAINE**<br>Qwgm | Generally too thin to be potential aquifer, and water table generally located in underlying bedrock.<br>Easy to moderately easy to excavate; maintain [illegible] poor foundation for heavy structures.<br>Useful as random fill but with limitation due to large boulders. |
| DEVONIAN | CATSKILL FORMATION | Gray conglomeratic sandstone and sandstone with some red siltstone and claystone arranged in several fining-upward alluvial cycles; cycles average 50 feet (15 m) in thickness; well-developed crossbedding in conglomeratic sandstone and sandstone; blocky to flaggy fragmentation in sandstone, and platy or hackly fragmentation in siltstone units; forms prominent main edge of Pocono Plateau escarpment; other sandstone ledges occur in steplike fashion north of escarpment; deposited in fluvial system dominated by braided rivers but with some periodic meandering streams on alluvial plain or upper delta plain; approximately 240 feet (73 m) thick. | **PACKERTON MEMBER**<br>Dcp | Little groundwater potential in this area mainly because of topographic position and thinness of member; production from underlying Long Run Member more likely.<br>Siltstones and claystones easily excavated, but sandstones and conglomeratic sandstones probably require blasting; generally maintain very steep cut slopes; excellent to good foundation for heavy structures.<br>Thicker conglomeratic sandstones may have potential as dimension stone; limited potential for crushed aggregate. |
| | | Numerous cycles of gray sandstone fining upward to red siltstone and claystone; cycles vary from 20 feet (6 m) to 100 feet (30 m) thick, averaging about 50 feet (15 m) thick; sandstones are fine to medium grained, usually crossbedded at base of cycles and grading upward to finer grained and planar beds; sandstones disintegrate to blocky to flaggy pieces; siltstones and claystones dominantly grayish red with some greenish gray; siltstones frequently arranged in many repeated fining-upward subcycles; siltstones and claystones disaggregate to platy, rubbly, or hackly pieces; member forms terrain of moderate relief with prominent sandstone ledges; deposited in fluvial system dominated by meandering rivers or streams on upper delta plain, but some deposition by braided rivers, particularly in upper part of member; maximum calculated thickness about 5,000 feet (1,500 m), but open to question due to potential presence of many folds covered by surficial material. | **LONG RUN MEMBER**<br>Dclr | Groundwater potential adequate [illegible] throughout area; average yield [illegible], with range of 1 to 60 gpm [illegible] water quality in general.<br>Siltstones and claystones moderately easily [illegible] and may require blasting; maintain [illegible] very steep cut slopes, but claystones may disintegrate rapidly when exposed to weathering; excellent to good foundation for heavy structures.<br>Some flagstone potential; some potential for crushed rock; red siltstones and claystones utilized in construction of low- to moderate-use roads; possible source of structural clay products from claystone intervals. |



Base map from U.S. Geological Survey Skytop 7½ minute quadrangle

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Geology based on field mapping during 1973.

Virginia M. Milewski, Cartographer

| | | | | |
|---|---|---|---|---|
| | areas, scattered boulders on ground moraine surface, no clearly established drainage pattern; deposited as compact lodgement till or as less compact and sandy ablation till during ice melting and regional deglaciation, widely variable thickness, ranging from 5 to 100 feet (2 to 30 m), with average thickness of 34 feet (10 m) | | | Useful as random fill but with limitation due to large boulders |
| DEVONIAN | Gray conglomeratic sandstone and sandstone with some red siltstone and claystone arranged in several fining upward alluvial cycles, cycles average 50 feet (15 m) in thickness, well developed crossbedding in conglomeratic sandstone and sandstone, blocky to flaggy fragmentation in sandstone, and platy or hackly fragmentation in siltstone units; forms prominent main edge of Pocono Plateau escarpment, other sandstone ledges occur in step-like fashion north of escarpment; deposited in fluvial system dominated by braided rivers but with some periodic meandering streams on alluvial plain or upper delta plain; approximately 240 feet (73 m) thick | CATSKILL FORMATION | **PACKERTON MEMBER**<br>Dcp | Little groundwater potential in this area, mainly because of topographic position and thinness of member, production from underlying Long Run Member more likely.<br>Siltstones and claystones easily excavated, but sandstones and conglomeratic sandstones probably require blasting, generally maintain very steep cut slopes, excellent to good foundation for heavy structures.<br>Thicker conglomeratic sandstones may have potential as dimension stone, limited potential for crushed aggregate |
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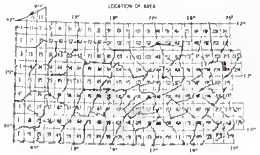
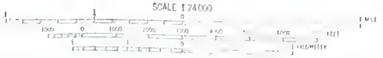
# GEOLOGIC MAP OF THE SKYTOP QUADRANGLE, MONROE AND PIKE COUNTIES, PENNSYLVANIA

BY

W. D. SEVON AND THOMAS M. BERG

1978

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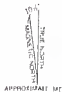
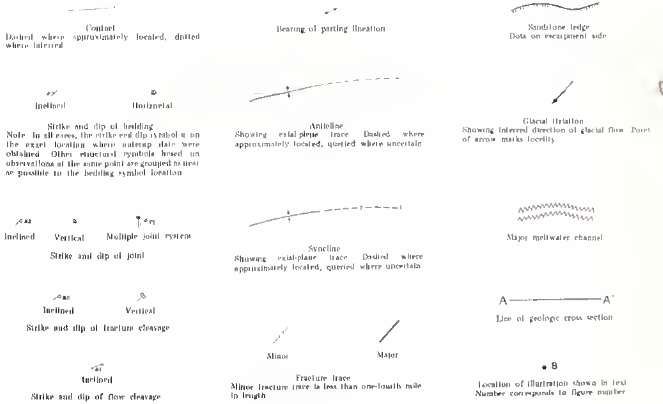
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL



APPROXIMATE MEAN DECLINATION 1968

## SYMBOLS



Contact
Dashed where approximately located, dotted where inferred

Bearing of parting lineation

Sandstone ledge
Dots on escarpment side

Inclined
Horizontal
Strike and dip of bedding
Note: In all cases, the strike and dip symbol is on the exact location where outcrop data were obtained. Other structural symbols based on observations at the same point are grouped as near as possible to the bedding symbol location

Anticline
Showing axial-plane trace. Dashed where approximately located, queried where uncertain

Glacial striation
Showing inferred direction of glacial flow. Point of arrow marks locality

Inclined
Vertical
Multiple joint system
Strike and dip of joint

Syncline
Showing axial-plane trace. Dashed where approximately located, queried where uncertain

Major meltwater channel

Inclined
Vertical
Strike and dip of fracture cleavage

Minor
Major
Fracture trace
Minor fracture trace is less than one-fourth mile in length

Line of geologic cross section

Location of illustration shown in text
Number corresponds to figure number

Inclined
Strike and dip of flow cleavage

## CROSS SECTION

(Scale same as map scale; no vertical exaggeration)